ANATOMY NOTES

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PREFACE TO SECOND EDITION.

Nearly all of the material of the first edition has been omitted in the present edition.

The notes are not final. They are incomplete and will be supplemented while dissection is going on.

These notes do not constitute a text but a student scrap book. It is written in English to ensure the student's knowledge of anatomical terminology in that language. Some Chinese terms are added. Blank pages are included for writing of additional notes and for the drawings of bones, cross sections and the pupil's own dissections.

In this college anatomy is taught during the first year of the medical course proper. The student has no previous knowledge of anatomical structure or function.

The study of anatomy without a concomitant enlightenment in physiology is a mistake; it also adds a considerable unnecessary burden on the student's memory; is uncorrelated and uncoordinated and detracts from its interest and usefulness. These notes will aim to give very briefly some information other than pure structure and morphology. The compiler has very closely followed that excellent study of "The Principles of Anatomy as seen in the Hand," by Frederic Wood Jones. He has also freely used "Simple Lessons in Human Anatomy," Harvey. Rather than destroy the consecutiveness of either story of these books there is some lack of regularity in the succession of these notes. The interpolation of the Chinese terms has been done by Dr. C. C. Fay.

Chengtu, 1931. W. R. M.

PREFACE TO FIRST EDITION.

This collection of notes is chosen from authorities with the idea of supplementing the anatomy in Chinese and to point out a few special anatomical, anthropological, and comparative anatomy features, and is intended for local circulation only.

The following are the authorities from which this material was collected: Gray, Cunningham, Morris, Tubby, Ellis, Encyclopedia Britannica, Tropinard's Anthropology, Tyler's Anthropology, Dixon, Peterson, Santee, Deaver, Campbell, Davis. If any are omitted, the name of the author is appended to the section where it appears.

Dr. E. C. Wilford has typed all the notes, interpolated Chinese terms, corrected part of proof, and greatly assisted by advice and counsel and to him I owe many thanks.

The compiler trusts that these notes will be of assistance to the Union University students.

W.R.M.

Confucius said: "I do not expound my teaching to any who are not anxious to explain himself: if, after being shown one corner of a subject, a man cannot go on to discover the other three, I do not repeat the lesson."

"The higher type of man makes a sense of duty the groundwork of his character, blends with it in action a sense of harmonious proportion; manifests it in a sense of unselfishness, and perfects it by the addition of sincerity and truth. Then indeed is he a noble character." Confucius.

" . . . . the failure to cultivate virtue, the failure to examine and analyze what I have learnt, the inability to correct my faults, these are the causes of my grief." Confucius.

A golden bed does not cure the sick, nor fine manners make a good man."—Chinese proverb.

"Search thine own heart; what paineth thee
In others, in thyself may be;
All dust is frail, all flesh is weak—
Be thou the true man thou dost seek."

WHITTIER.

FOREWORD—ADVICE TO STUDENTS.

The earnest attention of the student is drawn to page iii on which are quoted the three sayings of Confucius written over 2000 years ago and which could and do serve as a model or ideal for the most modern research teaching.

It is the very essence of education of students in self-reliance and independent study under controlled guidance. These sayings take for granted a student is in earnest. That he is not only not afraid to work but likes to do it. To fulfill this advice, sacrifice of time and bodily effort are of less importance while mental effort is great. These sayings do not imply that all students are of equal mental calibre—they do not say every student must be of the highest calibre but they do say without equivocation that every student must use all the ability he or she possesses in learning all he or she can *on their own initiative*.

The teacher gives sympathetic guidance. It is a controlled, coordinated, sympathetic relationship. We are all students together.

Confucius drew an ideal of the upright man. You should attain to his model. Not all will succeed but all must try to do so. Confucius' advice is as good today as it was in ancient times.

The profession of medicine is a sacred vocation. Not all should attempt to become physicians. Only those whose character, ideals, physical body and mental ability are clean and pure should remain in medicine.

These notes and all technical studies are aimed to assist the student in his life's work. A wholly rounded and effective practitioner must weigh factors besides purely technical elements. The student days of the practitioner begin in college and continue as long as life with mental vigor shall last.

ANATOMY

(G. 55)

Anatomy is the name given to that division of natural sciences which deals with the structure or organization of living beings. *Human* anatomy applies to the structure of man bearing in mind the fact that man is distinguished as a separate genus among primitive animals – an order of vertebrates.

Man is a vertebrate, and possesses an internal skeleton with a median longitudinal axis which is divided transversely by segments called vertebrae. The vertebral column, in the habitual erect position of the human body, is supported by pelvic limbs, and is surmounted by the skull. These limbs are for the purpose of progression, while the pectoral limbs are adapted as organs of prehension. A distinction common to nearly all primates is an opposable first digit and thumb.

The possession of milk glands, rudimentary in the male but well developed and important in the female, relegates the human to the class of mammals.

Descriptive terms indicative of position and direction vary in spite of structural homologues in vertebrates in general. There are wide differences regarding natural attitude or position habitually assumed, so that often "in front" in erect man is "below" in the quadruped. It is essential that the names used in designating structural parts shall be defined so that each term shall have but one significance. Also some terms now used are not applicable to lower animals and man.

For descriptive purposes the human body is supposed to be in the erect position, the arms hanging by the sides, and the palms of the hands directed forwards.

The body as a whole, as with most vertebrates, consists of two general divisions (*a*) axial, and (*b*) appendicular. The former is the body proper (soma) and the latter the limbs (membra). The middle plane of the body is called "meson", while "mesal" and "mesad" (ward) are adjective and adverbial inflections. The mesal plane is also the dorsoventral plane which also passes approximately though the sagittal suture of the skull and hence any plane parallel to this is a *sagittal plane*. A vertical plane at right angles to the mesal plane passes roughly through the centre of the coronal suture, such a plane is called a coronal or frontal plane. A plane at right angles to both mesal and coronal planes is called a *transverse plane*.

The terms "anterior", "posterior", "superior", and "inferior" have been used but the growing use of data from comparative anatomy and embryology to elucidate human anatomy makes the other terms better to indicate relative position in both man and animals. Thus *ventral*, *dorsal*, *cephalic*, *caudal* (together with adverbial derivative "ad") are preferable.

"Lateral" and "laterad" are general terms for sides of body.

"Dextral" and "sinistral" mean right and left, respectively.

"Central" (centrad) and "peripheral" (peripherad) are in general use, especially for blood vessels and nerves.

"Ental" means inwards, and "ectal" means outwards, "proximal" refers to the attached end of limbs, and "distal" to the free end. *Borders* or sides of the limbs are designated: ulnar or radial, anconal or thenar, tibial or fibular, patellar or popliteal. *Surfaces* are called flexor or extensor.

"Superficial" and "deep" are confined to descriptions of relative depth from surface of various structure.

"External" add "internal" are used in describing the walls of cavities or of hollow viscera.

Osteology is the description of the bones.
Syndesmology is the " " " joints and ligaments.
Myology " " " " " muscles and fasciae.
Angiology " " " " " heart and blood vessels and lymph vessels.
Neurology " " " " " nerve system and organs of special sense.
Splanchnology " " " " viscera, comprising the organs of respiration, phonation, digestion, reproduction, excretion, and internal secretion.

"THE HAND AND THE BRAIN."*

See "Nervous System"

The intimate relation of muscles and nerves necessitates an early description of some of the anatomy of the brain 腦 and its continuation into the body. The nervous system 神經系統 of which the brain is the main feature together with the spinal cord 脊髓 and the nerves leading from both, is the life of the muscles. Through the nervous system the muscles 肌肉 move and live and without it they die. The brain and spinal cord contain the nerve cells which are the life of the muscles.

Some of the data about to be given you, to those who have not dissected the brain, will be more or less obscure and it will necessitate your taking for granted it is correct, until you have dissected a brain for yourself and thereby proven

* Chap XXI, "The Principles of Anatomy as seen in the Hand" Jones.

the truth of the statements here written. It means therefore, for a short time, a feat in remembering the anatomy of the nervous system.

For the present let us take as an example the dissection of the hand, that exceedingly necessary organ of our body, and see how the muscles, joints 節关, tendons 肌腱, bones 骨, etc. are connected with the far off organ, the brain. This dissection will show the intimate relation of anatomy and physiology 生理學, and the same close connection with pathology and in a practical manner, the interrelationship of surgical and medical practices and our work in the dissecting room.

There are no distinctive specialisations, anatomical perfections or wonderful human adaptation that distinguish our human hands from that of a monkey or anthropoid ape. In fact, it seems as if the plan of our human hands is more primitive than theirs. Our hands are more primitive and unspecialised than the paws of the cat and dog.

Any movement of our hands is practically equally as possible in old world monkeys, i.e. those monkeys possess hands which are equally capable of movement as our human hands, but purposive actions, habitual in man, are more than those of monkey. The differences in the hands are not the movements possible in muscles, joints and bones but in the purposive volitional movements. A man does much a monkey does not do, though the latter has a brain quite like a man's yet he does not possess the power of mind whereby man chooses to perform or not to perform certain actions. The power of choice, the will to do or not to do, distinguishes man from animals.

It is a wonderful instance of the retention of a magnificent primitive structure in higher animals, and compared with the paws of a dog and cat or the fore-foot of a horse, those animals have advanced, from a primitive condition which we retain. As a cortically controlled structure the human hand affords striking evidence of man's superiority over all the other mammalia. It is not the hand that is perfect but the nervous mechanism by which movements of the hand are evoked, co-ordinated and controlled. In the development of the cerebral cortex 外層 man shows a wonderful superior development over other animals but not in muscles, bones and joints.

Voluntary purposive movements are initiated in man in a definite region of the cortex of the brain known as the Rolandic area (precentral or motor area) 司動區. The grey matter of this region consists of many nerve cells buried amongst which are socalled motion cells (giant cells of Betz or ganglionic cells of Bevan Lewis). These cells are the largest found in the cortex and in general shape are pyramidal or pyriform (in fact the cells are very frequently called pyramidal cells). Each cell gives rise to several lateral processes as well as an apical dendron 樹狀突 which proceeds to the surface layers of the cortex of the brain, and a great axis cylinder (neuraxon) 神經軸, which runs straight from the cortex towards the centre of the brain and thence to the spinal cord. These cells are distinctive of that part of brain which when stimulated produces movement of different parts of the body and when destroyed by disease or injury, leads to absence of movement or paralysis 癱瘓

In man this portion of the brain is a large field which occupies the cortex of the whole pre-central gyrus 腦回 on the lateral half of the brain, extending downwards to the cortex of the island of Riel 腦島 and upwards, over the superior margin of the hemisphere, 大腦半球 to the paracentral lobule on the medial surface. Compared with the brain of any other animal, man shows a very high development of this motor area, and of all those nearly adjacent fields of the cortex which are called association areas. Function of this field is studied by the behaviour of animals who have suffered damage to some portion of their central nervous system.

Many non-mammalian vertebrates 脊椎動物 can initiate coordinated muscular movement of the limbs. A brainless bird can fly and run in a coordinated manner because its power of initiating muscular movements is in its spinal cord. Even a mammal, e.g. a rabbit, may have the motor area of the brain removed and yet continue all its movements as if normal. In the rabbit its power of initiating movement is not in the cortex but in the basal ganglia 節底 (the corpus striatum) 紋狀體. In many lower animals no motor cells are found in the cortex of the brain, in the cat and dog quite similar cells are found. In the Simiadae (anthropoid apes) is found a definite Rolandic area.

Man has lost the use of his lower centres as a source for initiation of the greater part of limb movement. This control has been translated to the Rolandic area, i.e. in man there is re-representation for movement. By this is meant that the initiation of the movement takes place in the lower centres (corpus striatum) and may be largely of a reflex nature but its performance enters consciousness and will, therefore, is retained in memory, and will become associated with other memories from other sources of impression which have reached the cortex during its performance.

Re-representation on the cortex adds the possibility of advantages from memory, experience and association which may be termed the capacity for education. The animal is conscious (in the cortex) of movement, can remember what they have done and that the experience gained may lead to perfection of these movements. In lower animals most of the movement is subcortical (lower centers are of a reflex nature,) and only certain parts are cortically represented, hence are capable of being perfected. Other acts are not so represented. In man all voluntary movement is initiated in the cortex, and the corpus striatum is not a motor nucleus. By voluntary movement is not meant individual muscle representation and individual muscle movement, for movement is a picture of a complex act in which more than one muscle is concerned.

The motor areas of the brain are associated but are not distinct areas, and that area for the hand is large and has a peculiar particular situation surrounded by these areas of the trunk and face, with that of the foot a little more distant.

A low mammal first gains impression by smell, it tests the world by its nose. The olfactory 嗅 sense guides, and gets a large cortical area and the touch sensations of the snout region (lips and tongue) are added as information centres, and gain cortical representation. Then the eyes replace the nose in higher animals and the hand becomes the great testing member of the body. They test the world with their eyes and hand, a large visual area 視野 in the cortex and a large area for sensation and movement of the hands are typical of such animals. In the human brain the large hand area is adjacent to that where movements of the face are represented. It is the hand which gave man the intimate knowledge of the rest of his body and the rest of the world. It caused the whole mechanism for initiating pictured movements to become entirely cortical and the functions of the corpus striatum as a motor nucleus 核 was lost to man.

In monkeys the removal of the cortical motor area produces paralysis but this later on is to a great extent recovered. The recovery of the hand is most delayed. In man if the motor area is destroyed or damaged by disease, hemiplegia 偏癱 is produced. In man recovery represents no more than a restoration of parts of the brain somewhat damaged but not destroyed by the lesion. The damage to the hand is greater than that to the foot.

Since movements the of limbs are initiated in the cortex they are never reflex in the same manner as reflexes are carried out in lower cerebral centres of the cord, e.g. walking, playing piano, knitting. etc are repetitive movements seemingly reflex but they never become so. The human body has to "learn" so much that is natural to lower animals, i.e. his cortex has to be educated. The lower animal simply exercises an arranged reflex. One has to learn to swim but once educated one will be able to swim ever afterwards.

There are certain movements which have no picture pattern in the brain and the initiation of these is still lodged in the lower centres of the brain stem or spinal cord, we have no picture nor action pattern of the movements of our viscera. Our hearts and intestines move in a way unfamiliar to us and these so called involuntary movements are subserved by involuntary muscles and are not represented in nor initiated by, the cerebral cortex.

There are other actions in which involuntary muscles take a part which are not pictured or represented in the cortex of the cerebrum 大腦 and are hence in lower centres, e.g. sneezing is carried out largely by the voluntary muscles but initiation is lodged in the brain stem not the cortex. Coughing, yawning and stretching when carried out as reflex acts are due to the fullness of the dependant veins and the veinous condition of the blood.

MOTOR PATHWAYS

Motor fibres, route of; (1) corona Radiata 放線冠, (2) internal capsule 豆狀核, (3) peduncle of the cerebrum 大腦脚, (4) pons varelii 橋腦, in which they are broken into a number of smaller bundles by the fibres of the middle peduncle of the cerebellum (brachium pontis 橋腦臂). In this region, also, some of the fibres cross the mid-line to end in the motor nuclei of the cranial nerves 腦神經 (third, fourth, fifth, sixth, and seventh), (5) anterior pyramids, 前錐體; (6) pyramidal decussation, 錐體交叉; (7) anterior and lateral pyramida fasciculi 錐體束 of the cord. After ending in the motor nuclei of the cranial or spinal nerves the path is continued by a second neuron, 神經單位, and injury to either will cause paralysis of the corresponding muscle. The first neuron is called the *upper motor neuron* ; the second neuron is called the *lower motor neuron. When the first neuron is affected* e.g. in hemiplagia *there is paralysis in regard to voluntary control*, but the spinal (second) neuron being intact, the muscles are still subject to reflex stimulation through the cord, especially the so-called tonic impulses. Often the muscles are then and thereby thrown into a state of continuous contraction, i.e. spastic rigidity. *In lesions of the second neuron, i.e. lesions in the anterior root cells in the cord, there is caused complete paralysis of the corresponding muscles, there is neither voluntary or reflex control*, the muscles are relaxed and show more or less atrophy. 萎縮

The Motor Pathways:—The Betz cells have five lateral processes, and a stouter apical dendron which brings the cells into relation with other cortical elements, there is thus a link up of that cell complex which constitutes an action pattern. There is also one great axis cylinder or neuraxon, a prolongation of the cell body, which passes into the centre of the brain on the first stage toward the spinal cord. This journey ends when the neuraxon comes in connection with the spinal motor cell or cells upon which it exercises its influence. The broader outlines of the main tract will be indicated to get a rough picture of the cortical control of e.g. the hand as a motor agent of will.

The axis cylinder of the Betz cells stream from e.g. the hand centres of the cortex into the white mass composing the bulk of the brain substance, called the centrum ovale. In this mass are not only fibres such as these which pass from the brain to distant centres and are therefore called projection fibres, but also there is a large bulk of the white substance composed of short fibres running between neighbouring stations within the brain itself and are known as *association fibres* 聯合纖維 and *commissural fibres* 連合纖維. The large projection fibres gather themselves together in a thick band, elongated in the long axis of the brain and flattened from side to side in order to squeeze through the narrow interval between the grey masses lying at the base of the brain. The axis cylinders of the pyramidal cells in the motor cortex are arranged in linear series, the long axis of which is vertical. In this series those axis cylinders destined for the foot are highest in position and those for movements of the face are lowest. As this bundle streams past the basal nuclei the strands are twisted and the lowest fibres take the front place in the band which is emerging from the brain stem.

It is this fanlike readjustment of the down-streaming fibres which gives rise to that appearance of the white matter of the centrum ovale called the corona radiata 放線冠. That portion of the tract between the basal nuclei is called the internal capsule and it is compressed between the lenticular nucleus 豆狀核 on the outer side and the caudate nucleus 尾狀核 and thalamus 視丘 on the medial side. In the recess between the caudate nucleus and the thalamus the internal capsule is kinked inwards towards the cavity of the third ventricle, this kink is called the genu and the hand fibres run down just behind the genu.

Below the ganglia the motor pathway emerges from the cerebrum forming a part of those ropelike structures known as the cerebral peduncles and constitute the middle portion of the hand fibres which clothes the surface of the peduncles and is known as the crusta. Next the tracts from either side of the brain come close together as the two peduncles are bound into a common stem by the transverse fibres of the pons (pons Varolii). 橋腦 In the pons the length wise running motor fibres are separated by bundles running crossways. At the lower border of the pons the two motor tracts emerge as the pyramids, they are separated by the anterior fissure of the medulla. 髓 If this fissure be opened by pulling the two strands apart, about an inch below the lower border of the pons, it will be seen that nerve fibres are crossing from one side to the other. They are the axis cylinders of the motor cells of the cortex contained in the pyramids. This is called the *decussation of the pyramids*, 錐體交叉 and axons of the cortical motor tract from the right side of the head have passed over to the left side of the cord and vice versa. Thus in the cord the axis cylinders of the Betz cells of the right pre-central cortex are found on the left side and are included in the so-called crossed pyramidal tract.

The axis cylinders of the nerves which control the actions of the hand run in this tract to the level of the origin of those nerve roots from which are divided the motor nerves of the muscles acting on the hand, i.e. from the fourth lower cervical to the first dorsal nerves. In the anterior horn of the spinal cord are nerve cells from which axis cylinders go to the muscles. Around these spinal cells the axis cylinder of the Betz cells come to an end by passing from the pyramidal tract to the anterior horn and break up into fine filaments, these filaments mix up with filaments of the cells of the anterior horn. The mixture of cell filaments is called a *synapsis* 胞突接觸.

Thus we have an axis cylinder of a nerve running unbroken all the way from the cortical motor area in the brain and along the cord to end in an arborization (synapsis) in the anterior horn of the cord (the grey matter of the cord). This portion of the motor pathway is known as the upper motor neuron. The axis cylinder of the cell of the cortical area for the foot arise farther away in the brain from those of the hand but extend much farther down the cord.

It is this great difference in the necessary length of the upper motor neurons that accounts for the difference in size of the pyramidal cells. In the cortex the bigger the cells the longer the axis cylinder. The most important feature of the upper motor neuron is that it is a crossed pathway, most of the neurons change from side to side at the decussation of the pyramids; some of them do not cross there but are continued as a smaller tract in the spinal cord called the direct pyramidal tract, but all of the "direct" tract neuraxons have passed over at different levels via the anterior commissure of the cord.

Thus the crossing has been completed. The right Rolandic area of the cortex presides over the left hand and left Rolandic area over the right hand. Righthandedness is due probably to a larger left-sided brain, for the outline of the skull and other matters tend to point out that there is an asymmetry of brain toward a larger left half.

- The number of neuraxons in the pyramidal tract is not so great as the number of motor cells in the anterior horn, although they correspond with the number of Betz cells in the cortex. Therefore more than one cell in the anterior horn comes in contact with and is influenced by the endings of each cortical cell. More influence in initiating ordinary voluntary movement is carried on by the upper motor neuron than is carried from the cortex by the pyramidal tracts.

Considered as an entity the uppermotor neuron consists of several "private paths" 私路.

(1) The motor tract already described and the most important because through it volition is carried to lower motor neuron and then to moving part.

(2) A pathway from the cerebellum to the anterior horn cells - the cerebello-spinal tract -this influences co-ordination of the action of volition.

(3) The corpus striatum 紋狀體 has a pathway to the anterior cells, and influences voluntary movement—lenticulo-rubro-spinal tract— and damage to it causes a tremor in carrying out voluntary movement.

(4) Dieter's nucleus sends another influence from its site in the medulla in association with centres of the vestibular 前庭 nerve, this is the vestibulospinal tract, it has to do with balancing, in its absence staggering occurs.

For the proper performance of voluntary movement of muscles all four of these influences must be necessary.

The lower motor neuron starts as a motor cell in the grey matter of the anterior horn of the spinal cord, and terminates as a motor end organ in a voluntary muscle. It is a motor nerve cell with a neuraxon. It emerges from the antero lateral groove of the cord as one of the anterior or motor nerve radiales. It joins with others into a bundle of neuraxons which constitute the anterior or motor root of the spinal nerve arising from that segment of the cord.

The anterior root runs outward from the spinal cord and vertebral column and becomes entwined with the fibres of the posterior or sensory root and forms an element in the mixed (motor and sensory) spinal nerve to the arm and hand.

From the junction with posterior root the course of the lower motor neuron is complicated. *The lower motor neurons of any one segment of the cord do not pass directly to a definite muscle or group of muscles derived from that same segment, nor do all the muscles supplied by the nerves perform the same action. There is no one definite movement for a muscle or muscle group.* The motor neuraxon of any one spinal nerve have to supply muscles varied in site and in function. Some muscles draw their nerve supply from several segment and muscles performing the same movement and involved in the same act of volition may derive their nerve supply from several segments of the cord. Also the lower motor neuraxon having once been involved the posterior sensory root must sort itself out again. But there is no nerve which contains nothing but the neuraxons of the anterior horn spinal cells (i.e. motor nerves). In all muscular nerves 1/3-1/2 of all the myelinated fibres are connected with the cells of posterior root ganglion.

Hence there are extensive comings and goings of neuraxons from the different roots supplying a limb, readjustments have to be made and this is carried on by the formation of plexuses. There the motor and sensor fibres are sorted out and led into certain mixed nerves which traverse the limb and from these they come off again as motor nerves to several muscles.

For the arm there are 5 special nerves entering the plexus (brachial) 臂叢 The fifth sixth eight seventh and first dorsal nerves enter this plexus and from it the mixed nerves of the arm run to various muscles and to the skin, that is, the plexus is a junction where the lower motor neuron from the anterior horn of the spinal cord are despatched to a wide series of muscles. *In lower motor neuron paralysis, the muscle degenerates.* It is a muscle cut off from the source of its life.

The termination of the lower motor neuron in muscle is affected by motor end organs of which there are several varieties, the brush organ of Kuhne, plates of Rouget, hillocks of Doyere, those are distinct from muscle spindles (the end organ of sensory nerves). The path-way from the Rolandic cortex to the voluntary muscles is a comparatively simple route. It is a path of two neurons.

Regarding movement, this is a relatively circumscribed psychical condition, the initiating stimulus may be regarded as a volition to alter the position in space of a part or whole of the body, the direction of which in space is known to us. This act is modified only in so far as the paths from the cerebellum, vestibular system, and corpus striatum are brought to bear upon the lower neuron.

In tracing the nervous pathway from the various sensory end-organs to the so-called sensory area of cortex we are dealing with an exceedingly complex route.

SENSORY PATHWAYS:

In the sensory pathways, no matter what sensation we are attempting to follow we have to deal with three separate neurons not two. Sensation itself connotes an assemblage of separate qualities.

The lowest sensory neuron of the sensory cells consists in a ganglion cell lodged in the posterior root ganglia from which one branch of the neuraxon passes by the posterior root to the spinal cord and the other branch travels with the lower motor neuron through the limb axis and along the peripheral nerves of the limb.

The lowest sensory neuron, which runs in the sensory, mixed, as well as the motor nerves of the limb, terminates in various sensory endings in muscles, joints, tendons, membranes, subcutaneous tissues and skin. These lowest sensory neuraxons and their end organs subserve very different sensory impressions, e.g. superficial and deep sensibility, each of which is compound.

Superficial sensation may be touch, pain, heat or cold and it may be either epicritic 厄皮克梯感覺 or protopathic, 坡妥琵梯感覺 or it may be concerned with appreciation of separate stimuli and the exact localization of these stimuli. (Epicritic means serving the purpose of accurate determination, e.g. cutaneous sensory fibres showing fine variation in touch and temperature. Protopathic means the determination of strong stimulation of pain or temperature).

Deep sensation may be either the appreciation of pressure, vibration or of position in space. The ability of recognizing forms and nature of objects (stereognostic sense) is a combination of superficial and deep stimuli. Some of these different functions may be subserved by different types of sensory endings. It may be that there is an accompanying anatomical differentiation, but that is not proven. But in the study of injury to peripheral nerves it is clear that protopathic and epicritic, deep and superficial sensory factors may be affected individually and in combination and that the different peripheral nerves contain different factors in varying proportion. From the sensory end organs of the hand these impressions are streaming via the lowest sensory neuraxon carried by the median, ulnar, musculo-spinal 橈神經 and musculo-cutaneous nerves 肌皮神經. From these four nerves they pass into the brachial plexus and emerge on the central side in mixed trunks (the fifth, sixth, seventh, eighth cervical and first dorsal). From the mixed trunks they pass into the posterior root ganglion, then they pass into the posterior root (in the ganglion they join the body of the parent cell).

From the central side of this ganglion another cell brach (neuraxon) passes into the substance of the cord along the posterior root. These neuraxons in the posterior root are not of the same size fine and coarse - and are in more or less definite bundles. On reaching the spinal cord the fine fibres run for the most part to the side of the cord and the coarse fibres to the posterior aspect.

Within the cord the lowest sensory neuraxon ends by coming into contact with a cell in the posterior root of the grey matter 灰質 of the cord. It also, by collaterals, effects a junction with the cells (motor) in the anterior horn of the cord. This is the shortest path between the incoming sensory and outgoing motor impulses, and they complete the path for reflexes comparatively insignificent in man. Reflexes are essentially a protective mechanism in man. In lower animals it may be most complex, so that cells of the cord carry out highly coordinated movement.

The lowest sensory neuraxon, is a nerve cell of the posterior root ganglion with a centrally and peripherally running neuraxon, the first is a part of the posterior root of a spinal nerve and the second is bound up in a peripheral nerve 周圍神經. In the spinal cord their fate varies. They have in common, that they end in a synapsis around some cell in the grey matter of the cord and so make connection with the second sensory neuraxon. The level at which they end varies greatly, some end in sinapses almost immediately on entering, some run considerable journeys within the cord before they end in their first synaptic junction with a cell of the grey matter of cord.

The physiological principle and end attained by the comings and goings within the cord is a regrouping of neuraxons and a reclassification of the stimuli which they are carrying to the brain. The peripheral sensory nerve contains a dual superficial system of epicritic and protopathic fibres, also fibres of deep sensibility. It can inform the central nervous system of sensation of touch, heat, cold, pain, etc. The sensation of pain may be produced by superficial or deep or by epicritic or protopathic nerves. The myriad streaming stimuli into the cord is readjusted there. There is a regrouping consisting of an integration of all stimuli of one kind, no matter what their source. All fibres subserving pain, touch, heat and cold, no matter what is the source, are isolated into separate groups travelling up the cord.

Thus the individuality of the sensory peripheral neuraxon is lost after its second sensory neuron is reached, thereafter the sensations of pain, touch, heat or cold are housed in separate fibres or bundles, and the problem is now to separate the tracts which carry these sensations. The lowest neuraxon which conveys sensation of pain and temperature comes in by the same route, and goes into the posterior horn of grey matter of the spinal cord, here a synapsis is formed about a nerve cell which is the parent of the second neuraxon. This new neuraxon passes across the gray commissure to the opposite side of the spinal cord and runs upward towards the brain in the lateral white column of the cord forming a fibre in the ascending tract known as the spino-thalmic bundle. This tract runs from the spinal cord through the midbrain 中脳 as a leash of fibres known as the medial fillet, and there the fibres end in the basal grey nucleus named the thalamus 視丘 by forming a synapsis around a ganglion in the thalamus from which a third or upper sensory neuraxon takes orgin.

The fibres of pain and temperature cross at varying levels in the cord. Some run for some distance in the posterior column of its own side of the cord before forming a synapsis with the posterior root cell in grey matter and give rise to second sensory neuraxon; and some end immediately they enter the cord to posterior horn, ultimately they group in the lateral columns on opposite sides of spinal cord. The upper sensory neuraxon starts from the cortical area of the thalamus and travels to the cortex of the brain in the socalled sensory area of the cortex of cerebrum.

Touch and sensibility of contact fibres are more complex. Their continuation and regrouping takes place higher up in the spinal cord than those of pain and temperature. Upon entering the cord some end after a short course upward in synapsis around a posterior horn cell. From their cell the second sensory neuraxon of touch arises and crosses the midline to the opposite side of the cord, and takes up the rest of its course in the lateral column whence it runs via the fillet to the thalamus and establishes connection with the highest sensory neuron. Another and larger pathway is some of the fibres do not form synapsis till they have reached the top of the posterior columns in the spinal cord, 脊髓 and the second sensory neuraxon is therefore shorter than those which enter and form synapsis lower down the spinal cord and therefore have a longer neuraxon. All cross to opposite side of spinal cord. *Pathologically this explains why in injury of cord a patient may lose pain and temperature sensibility and not of touch.*

FIBRES OF DEEP SENSIBILITY:

These fibres on entering the cord remain uncrossed and ungrouped in the posterior columns of their own side, and they, with the temporarily uncrossed and unsorted fibres of pain, temperature, and touch constitute the two great fibre masses of the posterior column knows as tracts of Gall and Burdach or the funiculus gracilis and funiculus cuneatus. From these two columns the ungrouped pain and thermal fibres are constantly passing away to cross and become grouped as second neuron fibres in the lateral column of the opposite side of the cord. The fibres of touch are also passing away, though some remain in the posterior column for its whole length before crossing in the same way as fibres of deep sensibility. The dual nature of the posterior columns is just anatomical not specialised into different tracts.

The sensory fibres from the legs begin at the lowest extremity of the cord and those from the arm constitute a lateral addition to the original tract of the posterior column, i.e. those of the arm constitute the funiculus cuneatus 楔状索 (column of Burdach) and those of the leg the funiculus gracilis 薄索 (column of Gall). At the upper extremity of the spinal cord these two tracts swell out into two ganglionic masses known as nucleus cuneatus and nucleus gracilis which produce prominences on the dorsal surface of the medulla known as the "tuberculum cuneatum" 楔狀結節 and the "clava" respectively.

Within these ganglionic masses the lowest sensory neurons of deep sensibility come to an end in synaptic junctions with the cells of the ganglia. From these cells the second sensory neuron arises and passes upward in the fillet and in the fillet cross the midline by the sensory decussation of the mid-brain, and so pass to the "thalamus" of the opposite side of the body. From a cortical cell of the thalamus in which the second sensory neuron ends the upper neuron passes to the cortex of the brain. But many fibres of the posterior column go not to the thalamus but to the cerebellum. This silent system of instreaming afferent impulses is one of the mechanisms which form the intermediaries between deep sensibility and movement for it regulates and controls poise of moving parts and coordinates the impulses connected with muscle sense and the tone of muscles necessary to affect balance and posture.

The thalamus is the great sensory receptor. It may be compared with the corpus striatum 紋狀體 (cardate and lenticular nuclei), the great basal submerged cortical mass which initiated movement in animals. The thalamus and corpus striatum may be regarded, respectively as the sensory receptive and motor initiating mechanisms of the typical mammalian brain. But we have seen that the functions of the corpus striatum possessed in lower animals is not possessed in man, but has been usurped by the cortex of the brain.

What is the relation of the cerebral cortex and the thalamus?

The work of Head upon cortical war wounds of the brain during the war, shows that if the *motor cortex is destroyed it does not deprive the patient of movement, but does prohibit the performance of any movement of which the patient has any appreciation as an active picture of the part to space.* A man who has suffered injury to the sensory cortical part of the brain (post-central gyrus) can feel pain, touch, temperature (heat and cold) with the affected part but he cannot appreciate its position in space nor can he isolate or localise separate contacts made simultaneously, he is unable to estimate weights placed on the part or to realise the likeness or unlikeness of objects brought into contact with the part. Most of the fibres involved in these forms of sensibility are those carried as long sensory neuraxons in the posterior column of the spinal cord which we grouped as fibres of deep sensibility, and to which are added certain of the fibres subserving touch. It is probably justifiable to regard the columns of Gall 薄束 and Burdach 楔状索 and the nucleus cuneatus and nucleus gracilis, together with the crossed fibres of the fillet as the great pathway for the impulses of special appreciation and discrimination which are so essentially cortical in nature.

The work of Head has shown how dominant in the cortical sensory area is the representation of the hand as an appreciative organ. It would appear to be rare to find any disturbance of sensation after a cortical injury in which the hand is not involved. Head has shown that where the face is affected, the thumb and index finger will be likely to suffer too. This shows that the thumb and index inger are represented in the lower limits of the postcentral convolution, 腦回 i.e. the thumb and index finger areas as being added next to the snout area in the phylogenetic 生物系統學 building of the cortex.

The little finger is usually involved when a cortical lesion produces changes in the sensibility of the hand. We may therefore picture the sensory area of the postcentral convolution as being largely occupied by the discriminative sensibility of the hand arranged as a series of five individual digits from the pollex to the minimus as the area is followed upwards.

NERVES 神經

The nerves are complex entities consisting of neuraxons of different kinds well bound together into a common trunk by a wrapping of fascia which commonly contains fat and which is known as the "epineurium" 神經外膜. Within the trunk are separate subdivisions, termed funiculi, 索 each containing its own complement of neuraxons bound together by the "perineurium" 神經外膜 which penetrates within the thickness of the trunk.

Each funiculus is again permeated by finer derivitives of the same all pervading fascial tissue which under the name of "endoneurium" 神經內膜 envelopes each neuraxon and its own proper coverings. These invasions of fascia are almost entirely supporting and protective in function, for the blood vessels carried by them to the neuraxons are extremely small the neuraxon having very little blood supply.

It is this supporting fascia which gives nerves, as seen in dissection, great strength. It also produces the puzzling condition by which some nerves appear to grow thicker the further they are traced toward their terminations. The root nerves as they emerge from the brain and cord are of minute size, subsequently the nerve is of large size even after having given off neuraxons in its course. The further the nerve travels and the fewer become its neuraxons the greater the need for supporting fascia.

Within the thickness of the composite nerve the funiculi run a more or less independant course and it is now possible to determine with fair accuracy the position of the different constituents in different portions of its course, i. e. the motor fibres from one particular group of muscles, occupy a fairly definite and independant pathway along the course of any mixed nerve. This information is largely from experience in the war, when large numbers of cases occured when section of nerves and parts of nerves was made by bullets. Though the separate funiculi remain largely independant the tangling of the nerves varies greatly in different individual nerves, e. g. the musculo-spiral nerve 橈神經 may be easily frayed out into separate strands and one strand, say the nerve to an individual muscle may be dissected along the trunk for a considerable distance. In the case of the median, this is at times impossible, for in texture the median nerve is a tangle whereas the musculo-spiral is a bundle of parallel strands.

In the hand nerves most concerned are the "musculo-spiral", 橈神經 "ulnar" 尺神經 and "median" 正中神經. The musculo-spiral arises from the sixth, seventh, and eighth cervical nerves. It is a "motor" supply of the extensor muscles of the elbow, wrist and fingers and the sensory supply of the extensor surface of the limb. Above the elbow the musculo-spiral nerve divides into two branches which are continued to the hand. Of these the posterior interosseous consists nearly entirely of muscular branches and the radial is entirely sensory. From the musculo-spiral, branches run to the triceps 三頭肌 and anconeus 肘後肌 these muscles extend the elbow joint (seventh and eighth cervical roots); innervate the supinator longus and extensor carpi radialis longus (sixth and seventh cervical roots); the posterior interosseous sends muscular branches to the extensor carpi radialis brevis, the supinator brevis, extensor carpi ulnaris, extensor communis digiti, extensor minimi digiti and extensor indicis as well as extensors of thumbs, (extensor pollicis longus, extensor pollicis brevis, and extensor ossis metacarpi pollicis).

As far as the hand is concerned the motor effects of injury to the musculo-spiral are, therefore paralysis of the supinators, of the extensors of the wrist, and the extrinsic extensors of the digits. The classical symptom is "drop wrist". The fingers cannot be straightend out at the metacarpo-phalangeal joints but the terminal phalanges, may be extended by interossei muscles.

The radial consists of fibres from the sixth cervical nerve and is distributed to the skin over the back of the radial side of the hand. It is not an important nerve of sensation for the hand.

The median nerve is the most important of the nerves of the hand. It is derived from the sixth, seventh and eighth cervical roots with some fibres from the first dorsal. The sixth and the seventh cervical enter by the outer head, and the eighth cervical and first dorsal by the inner head, of its two heads of orgin.

This nerve is motor and sensory, all forms of sensibility to the pronator radii teres, (these are from sixth cervical) and the flexor muscles. The first motor nerve above the elbow joint goes to the pronator radii teres; just below the joint fibres go to the flexor carpi radialis, and a second lot to the pronator radii teres, all of these are from the sixth cervical. Motor nerves from the seventh and eighth cervical and first dorsal go to the flexor digitorum sublimus and to the palmaris longus, and a second and third set to the flexor sublimus. Other fibres supply the flexor pollices longus and the radial part of the flexor digitorum profundus.

It is continued down the forearm as the the anterior interosseous nerve which sends branches into the pronator quadratus and thence through the annular ligament to the palm of the hand. In the palm motor branches go to the abductor pollicis, the opponens, and the outer of the flexor pollicis brevis, and to the two radial side lumbricales muscles.

The sensory fibres go to the skin of hand, the first palmar cutaneous and five digital cutaneous, the first and second to the margins of the thumb, third to the radial side of index, forth to the index and medius and the fifth branch to the medius and the ring fingers and this last branch communicates with the digital branch of the ulnar. The median gives off many branches to bones, joints, ligaments and the interosseous membrane, 骨間膜 besides many branches to blood vessels. It may be said to almost possess a monopoly of nerve supply of the forearm. Its terminal branches have many Pacinian bodies 環層小體. As it passes into the palm, it swells into an almost gangliform enlargement of a pink grey colour (this colour is peculiar to this nerve and the distal part of internal polital as it enters the sole of the foot.) It also has in its midst an artery—arteria comes nervi—so also has the internal popliteal.

The median nerve supplies epicritic sensibility to the palmar aspect of the thumb, index, middle, and the radial side of the ring finger and to corresponding parts of the palm. On the dorsum of the hand it supplies epicritic fibres to the index, medius and ring fingers, over their two terminal phalanges. After injury there is protopathic loss on the palmar and dorsal side of the two terminal phalanges of the index and middle fingers and some to the palm of the hand. Over the same area deep sensibility, sense of position, and all sensation is lost. Also trophic changes (i. e. those pertaining to nutrition) occur. Motor loss is not so great an injury as is that of sensibility. This seems strange for the motor fibres of the median are many. The median supplies the whole of the flexor digitorium sublimus and the radial side of the flexor profundus; it would seem that if the median were cut off, the patient could not flex the first interphalangeal joint of any finger nor the terminal interphalangeal joints of the index and middle fingers. But we find if we ask such a patient to close his fist, he will be seen to bend all the joints of all the fingers. This is because the flexor profundus flexes the first interphalangeal joint after it has flexed the terminal joints of fingers and thus close them into the palm.

The reason for it is that the brain (volition) controls muscle action, not individual muscle, so when the mind desires to close the fist and some muscles that normally do it are injuried, it can and does, when ever possible, call another muscle to close the first. But if you isolate the index finger and have patient centre his attention on bending the terminal joint, thus he cannot do and thus the paralysis 猟 of the flexor profundus is clearly proven.

The ulnar nerve is a mixed motor and sersory nerve. It is derived from the eighth cervical and first dorsal. It lies on the back of the internal condyle of the humerus. It enteres the forearn between the heads of origin of the flexor carpi ulnaris which it supplies.

It then supplies branches to the flexor digitorum profundus, about two inches below the elbow joint. No further motor nerves come from it till it passes the annular ligament and enters the palam of the hand. In the palm it divides into two branches.

(*a*) superficial--the motor supply to the palmaris brevis, and (*b*) deep—the motor nerves to the intrinsic muscles of the palm. This branch supplies the abductor and flexor brevis minimi digiti, also the opponens minimi digiti, all the interossei, and the two ulnar side lumbricales. It ends in the adductor pollicis and the inner head of the flexor brevis pollicis.

After injury of the ulnar—motor effects result —the wrist can still be flexed by other muscles than the flexor carpi ulnaris, but the loss of the action of this muscle is shown by a deviation of the hand to the radial side. Loss of power by the interossei prevents spreading of the fingers or, the drawing them together except as far as the long extensors and flexors can perform that function and this they can do except for the little finger.

Loss of flexing action of the interossei and lumbricales 蚓狀肌 is marked on the meta-carpo-phalangeal joints, the deformity caused is called "griff or claw hand", which is caused by paralysis of the lumbricales and interossei, and then the entensor communis pulls the meta-carpo-phalangeal joints into hyperextension.

In case of the little finger the position is exaggerated, since four muscles (flexor brevis, abductor, interosseus and lumbrical) which produce flexion of this finger are paralyzed and two muscles (the common and proper extensors) can pull the first phalanx backward. This hyperextension of meta-carpo-phalangeal joint leads to passive flexion of two terminal joints which cannot be straightened back by the paralyzed interossei.

"Clawing" 爪形 of the medius and index fingers is not so marked, because the lumbricales of these digits is preserved; flexion of the meta-carpophalangeal joints is still possible. Nerve control to the adductor of the thumb leads to all grasping action between the thumb and index being performed by a characteristic pinching movement of flexion of the termiinal phalanx of the thumb through action of flexor pollicis longus. The ulnar nerve subserves all kinds of sensibility, after section, protopathic and epicritic are all lost as well as deep pressure sense and the sense of position.

THE SENSORY BRANCHES ARE THREE:

1. palmar: 2. dorsal; 3. superficial terminal to phalanges. The area of ulnar epicritic sensibility varies, as a rule it embraces the ulnar side of the palm as far as the middle line of the ring finger, all of the little finger and ulnar side of the ring finger. After injuary protopathic loss is complete, in all of the little finger and a corresponding strip of the palmar and dorsal aspects of the ulnar side of the hand. There is also a similar loss on the side of the ring finger next to the little finger.

Injury to the ulnar leads to loss of valuable muscular action as well as important protopathic sensation. The muscles supplied by the ulnar in the hand are the ones that perform fine movement and their loss in difficult to recover.

THE HAND AS SENSE ORGAN.

The *whole of the central nervous system is merely an internal portion of the general surface of the body of the embryo* 胚胎. The first beginnings of the neural axis including the brain, spinal cord and every other part of the complex of the adult nervous system are manifested as the sinking in of a lineal portion of the back of the ordinary epidermis 表皮 of the embryonic body.

Latter on this groove deepens and becomes buried in the tissues or the embryo and while this is occuring the neural crest (i e. the sides of the groove) fold over and meet in the dorsal line and the groove becomes a tube. It is from the some general epidermal covering of the embryo that the special organs of smell, taste, sight, and hearing are developed. The rest of the epidermal of the embryo left over after the central nervous system and special organs have been differentiated, becomes the skin and its derivitives, hairs, nails and teeth.

The central nervous system is a buried portion of the skin, or the skin is an exposed part of the central nervous system. The skin is the greatest and the most ancient of the sense organs of the body. It is the sensory covering which enables the animal to learn of its surroundings. As an animal moves forward the end of the body in front will need information because it first meet objects of the outer world. This skin may be regarded as becoming specialized into a more sensitive area and is the precursor of the cephalic sense organs of higher animals. But a sense organ is of little use unless it can learn from information. There is needed a connection between the sense organ and the deeper tissues of the body so the animal may react properly. A sensory impression must be able to produce a motor response. Cells from the surface layer may take up a deeper portion and so maintain connection with, and pass stimuli to, the cells specialized for producing movement. The anterior position of the nerve groove is the largest and best developed. Our central nerve system is, therefore, a portion of the skin surface buried in the body and connects cells which gather information from the outer world and the cells which are in the body. The brain is the enlarged end of the central nervous system. The skin and appendages are the external nervous system. In primitive animals 原始 the sense organ at the front end is olfactory 嗅 as well as tactile. 觸 The great fifth nerve area of the snout is the tactile field for information.

Vibrissae or "Whiskers" and sensory papillae are added to heighten the touch. The great Gasserian ganglion 半月神經節 becomes a sign post of importance on the trigeminal nerve. 三叉神經 when the lower mammal becomes clothed with fur the tip of the nose is naked, and it is kept constantly moist. In animals who depend on the sense of sight rather than smell the tip of nose is dry (usually). The moistening is scent-hunting animals is to detect direction of of air currents (wet a finger for direction of the wind imitates such a mammal).

When the mammal has a thick skin the muzzle skin remains sensitive. In flying, the olfactory sense ceases to be a guiding sense and sight impressions predominate. With climbing animals the eyes supplant the nose and the prehensile hand usurps the functions of the muzzle. This circumstance is a large advance. The hand becomes the organ to teach the qualities of its surroundings. In man it is more specialized than in any other animals. The hand grasps and works and is a specialized sense organ and a specialized sensory nervous system member. We learn through it of an objects' surface texture, (rough or smooth, shape and dimension, hard or soft, weight, solidity, hot or cold etc.)

The index finger plays the prominent part e.g. in digital examinations, it is another eye for the surgeon, or the listening ear. The thumb, index and radial side of the medial finger are most specialized. These are median nerve territory, that nerve, therefore is the channel by which the large bulk of our informative sensory stimuli is carried to the brain. In primitive mammals it is the fifth (trigeminal). in man the median nerve that carries the sensory stimuli to the brain. Cutaneous sensibility is of two types, epicritic and protopathic. Epicritic sensibility comprises light, touch, e.g. light piece of cotton drawn over finger. It also registers appreciation of temperatures between 23° and 37°C. as well as includes the ability to recognized and to separate simultaneous contacts. Proptopathie includes the more crude sensations, e.g. pair by prick of pin and greater degrees of heat and cold.

These forms of superficial sensibility must be distinguished from the appreciation of pressure, the sense of position of joints and the sense of vibration. Again the sterognostic sense, or the ability to recognize the shape and size of an object is a complex of both deep and superficial sensibilities. Such a classification affords a basis for all investigations on the peripheral nerves.

To subserve the sensory functions, the skin of the hand contains numerous sense organs in association with terminals of the sensory nerves. These end organs differ in type and special function, but their meaning and connections are by no means plain. Sensory nerves on approaching the surface of the skin divide into a vast of number of small terminal twigs ramifying in the subcuaneous tissues, (the deep cutaneous nerve plexus.) From this plexus fine filaments 絲 pass into the dermis where they again become interlaced and are known as the superficial cutaneous plexus and from this plexus the nerve terminals pass on into the epidermis. In each of these situations specialized organs occur, all of these are complex and are usually named after their discoverer.

In the epidermis, the first terminals of the nerves end spaces between the epithelial cells (Retzius), or they may join into a fine meshwork and apparently terminate in the cells themselves (Langerhans). They terminate as more definite end organs as the intra-epithelial baskets (panicrs of Dogiel) or as ivy tendril expansions of (Ruffiani).

In the dermis the terminations of the sensory nerves are very numerous and some appear to end as free filaments, 絲 and others are in association with definite end organs usually termed corpuscles. The best known are corpuscles of Meissner, 觸覺小體 of Timoffew, of Dogiel, and whorl forms associated with corpuscles of Ruffiani.

In the deeper layers of the dermis and in subcutaneous tissue occur the bodies of Vater, and Paccini, end organs of Gogli, Mazzoni and corpuscles or termial cylinders of Ruffiani. None of these end organs are the exclusive property of the hand, as they occur in other parts of the body. The intra-epithelial nerve terminations were first described by Langerhans in the skin of the palm and of the termial phalanges of the fingers but they occur in other sites. The ivy tendrils and basket end organs are said to be peculiar to mammals and are usually associated with sweat ducts, and are abundant on the palmer surface of the fingers, but occur in other sites where sweat ducts are numerous. These three types have been assumed to subserve the function of transmitting the lightest touch applied to the surface of the skin and therefore to be organs of epicritic sensibility.

Terminal end organs as Meissners corpuscles 觸覺小體 are the type we call tactile corpuscles or touch bodies. These are said to occur in man and monkeys and no other animals lower in the scale of life, they are however akin to structures described from muzzles of lower animals.

It is on the palm of the hand and the sole of the foot that they are most numerous. It is said that the palmer surface of the index finger tip has 100 to each two square milimeters, the second joint has 40 and the third point 15 on a like area. In the foot about 30 to two square milimeters on the last joint of the great toe, and seven to eight in the middle of the sole in a similar sized area. They occur on the nipple of the breast, scanty on the under or volar surface of the forearm and at the edges of the eyelids and lips as well as on the genital area. From the rest of the body they appear absent.

In spider monkeys they are found on the tip of their prehensile tail.

The sites of the Paccinian bodies in subcutaneous tissue are more familiar since they are the only terminals to be seen with the naked eyes. They are abundant on the palmar surface of the fingers. On a median nerve branch to a single finger there may be as many as 100. There are said to be 2000 Paccinian bodies in all the skin of the body, some 828 in fingers, soles 550, arm and forearm 322, legs and thighs 176, shoulders 24, buttocks 10 and 92 on the rest of the trunk. They are usually absent on the backs of the hands and feet and are rare beneath the skin of the neck. These bodies are found in deeper situation in connection with nerves to the external genitalia 生殖器 and the mammary gland. They occur on the nerves to the periosteum and on those supplying interosseous membranes, joint capsules and tendons, in large numbers in the thoracic and abdominal viscera in connection with the plexuses of the sympathetic nerves, 交感神經 upon the peritoneum 腹膜 and pleura 胸膜 and within the mesentery where sympathetic filaments terminate. Corpuscles of Ruffiani and Gogi were described on the palm of the terminal phalanges and in other situations, these are not organs of touch in the usual sense. From association with nerves supplying joints they are supposed to be connected with the appreciation of position in space. They are said to be the termination of vaso-motor nerves or to be connected with sensations of pain. They are said to be associated with sense of pressure and also with causalgia. In the body they are associated in hollow cavities with sympathetic nerves and may be sympathetic nerve terminals.

SYMPATHETIC NERVES OF THE HAND.

The mechanism of the muscle pump for the return of venous blood from the limbs, is a part, but a very small part, of the complex machinery which adapts the circulation to the functional demand of the individual or its part during varying phases of activity. Beyond the crude driving power of the heart muscle on arterial blood, and the influence of respiratory movements and muscular contraction on the return of veinous blood, there is needed a more subtle influence to regulate the force and rate of the heart and the bore of the blood vessels, and thus maintain the blood pressure which sustains and maintains the circulation of the blood.

This subtle influence is afforded by a system of nerves know as the sympathetic or autonomic nervous system.

Although the regulation of the circulation and its adaptation to temporary stress is but a part of the functions of this complex system of nerves, it is its most outstanding role. The exact and full function of the sympathetic nervous system is not understood and much of the interpretation of the functions is speculative apart from its purely visceral aspect.

Primitively (phylogeny, 生物系統學 ontogeny 個體生活史) and functionally the sympathetic nervous system is in the most intimate relation with certain chromaffin cells (pigmented cells) which constitute the elements of the ductless gland known as the adrenal. The adrenal produces an internal secretion 內分泌 which, like the sympathetic nerves, and, in conjunction with their influence, acts upon the circulatory system and raises the blood pressure.

In the human adult the chromaffin cells are mainly found in the medulla of the suprarenal bodies and the sympathetic nerve cells in the various ganglia of the sympathetic chain and visceral plexuses; but both sets of cells have merely wandered from the central nervous system to these sites in the process of development.

The parent cell of the lowest motor neuron is situated in the anterior horn of the spinal cord, within the tissues of the spinal cord; but the similar cell of the sensory neuraxon has migrated from the substance of the spinal cord to the posterior root ganglion. The sympathetic cells have migrated farther and are situated in outlying ganglion strung as beads along the sympathetic chain, scattered in various visceral plexuses or in the walls of viscera, or, have been even segregated in a so-called ductless gland. Such is the essential nature of the sympathetic nervous system. Its ganglionic cells have wandered from the axis of the central nervous system where they were together and have taken up stations in outlying parts. The separation of the sympathetic nervous system from the spinal or somatic system of nerves, is more apparent than real, and the separate functions of each as independent identities is not easy. Although these cells have wandered from the central nervous system it remains connected with that system by a nerve fibre. This fibre may be regarded as a spinal tract drawn from the cord as the cell migrated. Such fibres are known as pre-ganglionic fibres or white rami communicantes. They leave the cord via the roots (mainly anterior root) of the spinal nerves and, freeing themselves from this connection, travel to a far or near sympathetic ganglion where they come in connection with the nerve cells of the ganglion. These pre-ganglionic fibres are of small bore and generally have a medullary sheath 髓鞘 which is present in the typical somatic spinal nerves and which gives them their white colour (hence the name white rami communicantes).

The course of the preganglionic fibres in the central nervous system is not definitely determined. They have been traced to the nerve cells of the grey matter of the lateral horn of the spinal cord, and some observers have traced them to the dorsal nuclear cells (Clark's column) 背核 and also to the cells of the anterior column. These fibres do not emerge from the cord by roots of all of the issuing spinal nerves. They are concentrated upon a comparatively few segments. All the preganglionic fibres which join the sympathetic system proper are derived from that limited area of the spinal cord between the first or second thoracic nerves and the first or second lumbar spinal nerves.

An outflow similar in general disposition takes place from certain cranial and lower sacral nerves. These do not join the sympathetic cord but pass to distal visceral ganglia where they connect with ganglion cells and from which they are distributed as post ganglion fibres, the para-sympathetic nerves 副交感神經 of the head and pelvis.

The sympathetic outflow does not pass to the ganglia of the sympathetic chain in those regions of the cord from which the great limb plexuses are derived. To summarize: the upper neuron of the true sympathetic system consists of a cell in the grey matter of the lateral horn of the spinal cord, and a neuraxon which leaves the spinal cord between the limb plexuses and passes along the roots of thoracic nerves. It leaves this nerve as one of the white rami communicantes. This preganglionic fibre runs a course of varying distance and ends by coming into contact with one or more cells situated in a ganglion of the sympathetic chain.

From the multipolar cell of the sympathetic ganglion a new neuraxon arises and, as a rule, these have no medullary sheaths, hence are not white, therefore, the lower sympathetic fibres are grey and semitransparent and, as a consequence, are hard to distinguish in gross dissection.

Some of the fibres (posterior ganglionic) pass to spinal nerves in the grey rami communicantes and are presumably distributed with the terminals of these nerves. Some of them pass to the vessels and are carried to outlying parts along with the walls of the vessels, others go straight to glands or involuntary muscles which they innervate. Every spinal nerve in the entire series of them receives its contribution of postganglionic fibres via the grey rami communicantes, but only these nerves in the interval of the limb plexuses give off white rami communicantes or preganglionic fibres. These postganglionic fibres of the sympathetic pass to all nerves of the cerebro-spinal system.

Although the spinal nerves receive a very definite share of these fine non-medullated sympathetic fibres that is not the only method of their distribution to the tissues of the body. Many probably go via the blood vessels of the limb and they are found in visceral cavities. Other methods of distribution are still to be found.

As to function, the fibres so far considered are motor in function and efferent in impulse flow. In brief, these fibres activate a large range of tissues without the intervention of any conscious volition. They dilate the pupil of the eye, produce "goose-skin" on the body, erect the hairs, and produce a secretion from the sweat glands; 汗腺 they quicken the beat of the heart, act on the muscle in vessel walls, raise the blood pressure and determine the flow of the blood to the muscle, lungs and brain instead of to the walls of the vessels of the alimentary canal; 消化道 they act on the glands of internal secretion, 內分泌 and on the metabolism 新陳代謝 generally in such a way as to render the best possible service to the organs called upon for bodily defense. *The whole of their activity is a mechanism for self defense.* It is an involuntary activity called forth in response to fear or pain and it fits the animal for the struggle which in animal life is liable to follow the receipt of an unpleasant sensory impression.

But when we turn to the afferent or sensory side of the sympathetic we find our knowlege is very scanty. Sensory nerve endings have been described by many observers in viscera which have a sympathetic supply, in fact, there are few viscera in which free sensory nerve endings of fibres, presumably of this system, have not been recorded.

The details of the course of these fibres is very meagre. The fibres are medullated, they are larger than the ordinary preganglionic sympathetic fibres and apparently make no connection with sympathetic ganglion cells but pass directly to the cord through white rami communicantes. These are not the only free sensory nerve endings, because the Pacini-vater corpuscles in the mesentary, retro peritoneal tissues and other sites in visceral cavities are the endings of this system of nerves. We may suppose then that these similar bodies on digital nerves (Paccinian bodies) 環層小體 are also terminals of sympathetic sensory nerves. We know that there are efferent sympathetic fibres passing into the limbs by the postganglionic grey communicantes to the nerves of the brachial plexus, it is therefore possible there are also afferent sympathetic fibres in the limbs, part at least of which end in the Pacini-Vater end organs.

The actual distribution of the sets of fibres in the limb is not known. We know that effects which in other parts of the body are known to be produced by efferent sympathetic fibres are brought about by affections of the median nerve, and in a less degree of the ulnar nerve. And in the lower extremity sympathetic effects are mainly evoked by affections of the internal popliteal nerve. We therefore assume that the median, the ulnar, and internal popliteal nerves carry sympathetic efferent fibres because of the many Pacini-Vater corpuscles which crowd their terminals; and we suppose the same nerves to be the agents which carry the efferent sympathetic fibres of the limb.

The afferent sympathetic fibres from the viscera, are said to reach the spinal cord mainly via the white rami-communicantes 交通枝 but their route is not as open as that in the cases of the nerves of the limb plexus. In dealing with the sensory pathways of the posterior root we know the fibres are not all of the same size and some of them remain in a fairly distinct bundle which is smaller in size than the spinal nerve fibres. These fine fibres on reaching the cord run to its lateral aspect, unlike the larger fibres which run to the posterior column, and it is extremely likely that these fine fibres are the afferent sensory element of the sympathetic system of the limb.

Just why the fibres of the median and the internal popliteal nerves should show such individuality in the sympathetic qualities is hard to guess, but we have noticed that in the visceral cavities sympathetic nerves are commonly distributed along the course of the vessels and we have seen that the original courses of the main arteries of the limb are along the course of the median and internal popliteal nerves. With these nerves there are the degenerated remnants of the ancestral (i.e. embryological) arteries, and it is not impossible that their ancient complement of sympathetic fibres is added to the nerves with which they have become incorporated.

What phase of sensation then is the province of the sympathetic nervous system? Dr. Head says "The internal organs are supplied by the protopathic system, there is no controlling epicritic mechanism." The internal organs are supplied from the anatomical sympathetic system and therefore the physiological protopathic may be the anatomical afferent sympathetic system. This is significant for protopathic sensibility is a primitive, crude, diffuse sensation of pain or comfort. Protopathic sensibility warns the animal it is being hurt but gives it no specific information as to where the irritant is located That protopathic sensibility, even in the limbs, is a function of afferent sensory nerves of the sympathetic system is a probable assumption. Further investigation of the sympathetic nervous supply to the limbs is necessary.

THE VASCULAR CHANNELS OF THE HAND.

The study of the vascular mechanism involves a study of arteries, veins and lymphatics, the first brings the blood to the parts and the other two return various elements of blood to the heart. *Physiogenetically the separation of the veins and arteries from the lymphatics is only a question of physiological specialization in a primitively single system.* The vessels carry the mobile wandering tissue cells (white corpuscles) 白血球 and the nonmobile oxygen fixing bodies (red corpuscles). 紅血球 Of these two duties the first is the more ancient physiological role.

The primitive vascular system may be considered as one in which only white corpuscles and fluid plasma move through the body in a series of tissue spaces—a primitive lymphatic system. Then in phylogeny a respiratory function is demanded of circulating fluids and there are added oxygen carrying bodies to the stream. In the lowest vertebrates 脊椎動物 there is such a system—a lymphatico-haemal circulation. Finally specialisation leads to a separation into more or less separate entities. In the embryo, no matter what their adult condition, all the peripheral vessels are developed alike as tissue spaces which afterwards become confluent and form a connected system of channels.

The channels ramify through the whole body communicating freely amongst themselves and at a later stage communicate with the central pulsating organ (heart) of the circulatory system. The solid constituents of the blood are developed amongst the tissue spaces and for a time the contents of all the tissue spaces (no matter whether destined to be arteries, veins or lymphatics) are the same. That is, the lymphatic channels of adult life contain in early embryonic life both red and white corpuscles. As soon as the stage in embryonic 胚胎 life is reached when there is definite motion given to the fluids, a change occurs in the contents of the channel which are ultimately to become lymphatics. The contents move on towards the central pulsating organ of the circulatory system and red and white blood corpuscles flow to the heart both from the veins and lymphatic channels. Both sets of corpuscles pass out again along the meshwork of tissue cells destined to be arteries. But although the red cells find their way back from the arterial meshwork to the venous meshwork they are never able to negotiate the tissue spaces between the arterial meshwork and the lymphatics. The mobile white cells and the plasma may return by lymphatic channels but the red cells having once passed to the heart never again find their way back to the lymphatics from the terminal ramifications of the arterial channels. The veins alone are able to admit all three elements of the blood by ultimate radicles in tissue spaces. When the earliest stage of lymphatics is passed they cease to be blood vessels in a strict sense.

Lymph flows, therefore, centralwards in the lymphatics, while blood flows centralwards by the veins, and in this way the two systems have become to a certain extent separate by specialisation. But the connection between lymphatic and venous circulation is not limited to the entrance of the thoracic duct into the veins at the root of the neck. Late discoveries show that the lymphatics communicate with the veins at many other places. The lymphatics may be regarded as being a part of an older circulating system upon which the newer one has been grafted.

It differs from the venous system mainly from the fact that corpuscles which enter into the veins are debarred from finding entrance into its terminal ramifications. All vascular (vessels) channels originate in tissue spaces and are at first plexiform and from this plexus the adult channels are formed as development proceeds. Some animals, (the lemurs), have a plexiform arrangement of the limb arteries as in the adult.

In the arm, this primitive arterial plexus 動脈叢 is situated in the midst of the limb and follows the course of the median nerve. In the adult condition that channel has been modified by the development of side branches which dominate in impertance the older central axis. The adult axillary and brachial arteries represent the primitive arterial system as far as the elbow joint, but below the elbow joint the primitive channel is dwarfed by the developement of two new channels, the radial and ulnar. The old channel persists in the anterior interosseous artery which runs between the two bones of the forearm and in the arteria comes nervi, or median artery, which adheres to its old course along the median nerve. Usually the median artery is an inconsiderable channel which plays no part in the blood supply of the hand but it may persist, in a primitive form, as a large vessel and may contribute to the arterial arches of the palm of the hand.

The radial artery (from which the pulse is felt) and the ulnar arteries are both new channels. In the palm of the hand they form the anastomotic arches from which the ultimate arteries are given off. There are usually two arches, superficial and deep. The superficial arch lies superficial to the long flexor tendons and is mainly from the ulnar artery, the arch is completed by a small radial artery branch (arteria superficialis volaris). The radial branch may be missing, then the arch is incomplete on the radial side, or, some branch of the radial to the forefingers or thumb, or, the median or the interosseous artery 骨間動脈 may join the ulnar in the palm. Usually four digital branches from this arch go to the four fingers.

The deep arch lies on the metacarpal bones and the interosseous muscles, below the other muscles of the hand. It is made up of deep branch of the ulnar meeting the main branch of the radial artery which enters the palm from behind the thumb. As a rule three interdigital branches arise from the arch and run to interdigital clefts 指叉 and there join with arteries from the superficial arch and supply the adjacent sides of the fingers. The digital arteries run with the digital nerves along the sides of the finger supported by Cleland's ligaments and beneath the terminal pads of the fingers the arteries of either side unite into a complex terminal anastomosis. There are other arterial branches to muscles, joints, bones, and tissues of the hand.

The primitive veins of the upper limb were more plexiform and more tortuous than the arteries and are often very variable in distribution in the adult. Early in embryonic life the veins of the upper limb consist of preaxial and postaxial marginal plexuses which run along the superficial aspect of the two borders of the limb bud. Of these two the postaxial, or ulnar is the largest and most important and is phylogentically the oldest. This is the primitive vein which in the adult composes the brachial, axillary and subclavian veins. The radial side (preaxial) is found in the cephalic vein. There are deeper venous channels with the arteries.

The adult superfiical veins run between the skin and deep fascia and are of greater extent than the deeper veins, they are mostly on the dorsal and few on the palmar surfaces. On the dorsum they start as complicated networks around the terminal phalanges, from this two vessels emerge and run along the two sides of the dorsum of the digit and are connected across the digit by cross channels. At the interdigital cleft the superficial veins join with deep veins, thence across the dorsum of the hand to the wrist. As rule a large and distinct channel runs along the ulnar side of the dorsum of the hand from the interdigital cleft between the minimus and annularis. A belief in a particular direct channel from the veins of the little finger of the left hand to the heart comes from the dark ages of anatomy. This vein becomes the ulnar vein communicates with deep veins at the elbow joint and then becomes the basilic vein. This is the old blood letting vein "in the right arm hepatic or liver vein because it is opened in liver diseases", on the left "lienaria 脾 or spleen vein as it is opened in diseases of the spleen" The basilic becomes the axillary. On the radial side the plexus becomes the ancient cephalic vein, now the radial and it joins the axillary. "Cephalla" because it was opened in diseases of the heart." Veins of the palm are few and join to form the median vein, at the bend of the elbow it joins with the deep veins and a large trunk is formed which at once divides into the basilic and cephalic.

Deep veins of the hand cluster around the arteries and are called (venae comites). 並行靜脈 In the palm of the hand they are very numerous and give fierce bleeding in operation. This is due in the hand (as in the scalp) to the density of the tissues with which the vessels are surrounded and they prevent retraction, contraction and closure of the cut ends. These veins are buried deep beneath the palmar fascia. The deep veins are buried deep beneath the palmar fascia. The deep veins communicate at the base of the fingers and at the wrist with the superficial veins and are continued to the elbow as venae comites i.e. with the arteries. They there again communicate with superficial veins and again join the arteries and end as the axillary vein.

In the hand, forearm and arm is shown a general principle the same as in all parts of the body, viz:—whenever veins run in the midst of muscle masses they always assume plexiform multiple and incompletely valved channels. The venous channels around the brachial artery are not a discrete branch or branches but are a maze of pathways that enmesh the artery. Therefore in tying the brachial artery one finds an amazing number of vessels from which blood oozes out. This occurs in a mass of muscles. But where veins are free from muscles they exist as discrete single and valved channels.

The reason of this arrangement is a highly specialized adaptation for the purpose of securing the return of venous blood from the limbs. When muscles contract they squeeze blood from veins in their midst and press it onwards in the discrete and valved channels (to prevent blood returning from its source) which emerge from their masses. The muscles of the hand squeeze blood to more or less discrete veins at the wrist, the muscles of the arm press the blood in the venae comites into the valved axillary vein and so to the subclavian and the heart. The heart muscle pumps the blood along the arteries to distal parts and the blood is returned along the veins by the muscle pumps of the limbs.

These limb pumps are arranged as a series of syringes, each pressure area passing the blood through valved channels to the next pressure area. This system is further adapted (physiologically) by the superficial and deep set of veins which communicate in the intervals between muscle masses e.g. near joints. The superficial veins of the body are situated outside the ensheathing fascia of the muscles and so are shielded from muscle pressure and they are disposed in positions where external pressure is avoided. The deep veins of the palm are many, the superficial are few that is, where pressure may be great the veins are many, where little pressure the veins are fewer, In prolonged pressure of muscle masses in long sustained muscular effort, the deep veins are subjugated to much pressure and the blood is pressed to the superficial veins. Thus an alternate route is offered to the blood at every interval between muscle masses e.g. at elbow and wrist, i.e. at joints.

The deep veins are supported from overdilatation by the muscles and by the elastic stocking of the deep fascia overlying and surrounding every muscle, but the superficial veins have not this support. When the arm is in a quiet state (hanging down at the sides) the blood gravitates and the quiescent veins in the muscles are filled with blood and the superficial veins are engorged with blood as well. With returning activity the muscle pump of the limb comes into play and the return of blood is accelerated. It is to be noted as well that the opposite condition of long continued muscular effort produces engorgement of superficial veins by sustained pressure on the deep veins. Thus it occurs that two opposite conditions may lead to an extra burden of venous blood in the superficial veins and thus in the lower limbs produce permanent dilatation know as varicose veins.

The pressure of valves in the veins of the forearm may be easily demonstrated by placing one finger over a vein on the dorsum of the hand and so prevent blood from flowinginto it from the finger, if while this is being done, the vein be emptied by running another finger along it towards the elbow, it will remain empty for an interval; the blood being pushed up beyond a valve prevents the vein refilling from above while the pressing finger prevents entry of blood from below.

LYMPHATICS 淋巴

The lymphatics, like the veins, are thin-walled, tortuous and valved channels, but since the contents are colourless the ramifications in the tissues are not so familiar in anatomy as they are in pathology. At intervals lymphatic vessels are in connection with lymphatic glands. Lymphatic glands are usually situated in what are called quiet spots of the body, none are found in the hand, wrist or forearm until the elbow is reached and then one to three glands are found over the internal epicondyle 內髁 of the humerus. Large numbers of lymph glands in the axilla, 腋 others usually small and inconspicuous are occassionally found in the intermuscular interval between the pectoralis major and the deltoid where is lodged the cephalic vein. The next lymphatic glands are found above the clavicle at the root of the neck. In addition to these superficial lymphatic glands there are found (few and variable in size) lymph nodes along the course of the artery in the arm. As for the lymphatic vessels, a general rule for the whole body, that superficial lymphatics accompany veins while deep lymphatics accompany arteries, hold good. Deep lymphatics accompany all the arteries of the hand forearm and arm.

Cutaneous lymphatics compose a maze of anastomotic channels which surround the finger, run on the palmar and dorsal surfaces of the hand and weave themselves into various lymphatic pathways which follow the lines of the superficial veins. It therefore comes about that lymphatics *from the ulnar* *side* of the hand follow the course of the vena salvatella and the basilic vein and so connect with the *glands at the internal epicondyle* 内上髁 *of the humerus*. Lymphatics from the *palmar surface* run with the median and cephalic to the axillary glands and the bulk of the dorsal lymphatics follow the same course but some channels do not end in the *axillary vein* for they run in the intermuscular interval between the pectoralis major and the deltoid with the cephalic vein, and following the primitive course of the vessel, communicate with the glands above the clavicle.

The lymphatics which follow this course are mostly those derived from the dorsum of the thumb and index finger and although there is no real scientific belief for the old established idea that wounds of this area are liable to be followed by grave consequences, it is certainly true that the lymphatics from this dreaded area of the hand run a longer course free of the intervention of lymphatic glands than any other vessels in the forearm.

THE MUSCULAR ACTION OF THE HAND:

In the study of the muscles of the hand we limit ourselves to a study of skeletal, striated, or voluntary muscles. The skeletal muscles have always been known as voluntary muscles since they are said to be under the control of the will, in studying any individual skeletal muscle this needs definition e.g. supinator brevis (a typical voluntary muscle). We may know where it is, what it looks like, what nerve supplies it, but there is no power of the will to send an impulse along the nerve and make it contract. It is not under the control of the will as an entity, the will cannot make it move. Before we can make a voluntary muscle contraction of the supinator brevis we must know what action it produces in the body. From its disposition and a knowledge of limitations produced by its paralysis we conclude it acts in supinating the forearm.

The act of supination of the forearm in under control of the will and in this action the supinator brevis takes a part, it acts in voluntary movement and only to that extent is it voluntary. It is the movement of joints and parts and not action of muscles which is voluntary and under control of the will, "*movements not muscles are under control of the will*". In the gray matter of the motor areas of the brain are represented the movements of the body of which the animal has a pictorial knowledge and it is from these cortical areas that those conscious pictured movements are initiated. We can will by an effort of the cortex those movements of which we have a concrete and conscious conception. But there are other movements of which we have not a concrete mental picture and these are initiated not by the cortex but from basal ganglia of the brain. In carrying out these movements the non-striated or involuntary muscles are largely employed, and these muscles are involuntary not because they are in themselves less under the control of the will than are voluntary muscles but because the movements they perform are not the movements of which we have a full pictured knowledge, which are not represented in the cortex and so are not under control of the will. We have a definite picture of the action of bending the finger, this is initiated in the cortex and therefore is under the control of the will. The muscles which produce the bending are said to be voluntary muscles. We have no picture in the cortex of the closing of the pylorus 幽門 of the stomach, that action is initiated from a lower centre and is therefore not under control of the will. The muscles which produce the closure are said to be involuntary muscles.

But in several involuntary acts we have no cortical picture e.g. sneezing, many of the so called voluntary muscles play a part. Sneezing is not initiated in the cortex and the action of the voluntary muscles taking part in it is determined by lower centres. Now suppose a damage to the motor cortex destroys an area which contains the action pattern of a voluntary movement in which a certain voluntary muscle acts, then, this action cannot be performed and the muscles which should produce it are "paralyzed." But some of these muscles may take part in an involuntary action as some of the muscles attached to the arm do in sneezing; then when the involuntary act is performed, these muscles, which are completely paralyzed for the voluntary act will contract in a perfectly normal way.

A voluntary muscle may therefore be paralyzed for a voluntary or pictured action and yet be free to act in an involuntary or unpictured action. *The distinction between involuntary and voluntary muscles is therefore, rather one of the actions in which they are employed than of an actual characteristic of the muscle itself.* No part of the body displays the function of the voluntary muscles better than the hand, for no other part has a greater range of purposive voluntary movements.

A muscle is a contractile mass of tissue which is fixed at two extremes to some firm structures e.g. bones. When a muscle acts it is usually so placed anatomically that one end is relatively fixed, and the other is free to move.

The end that is relatively fixed during action is termed the origin and the free-to-move end the insertion. Thus the flexors of the fingers have their origin in the relatively fixed forearm or arm and their insertion in the moveable bones of the fingers. But the terms "origin" 起 and "insertion" 止 cannot be used in any hard or fast manner for the fixed extremity in one action may be the free end or moveable insertion in another motion; the rectus muscles of the abdomen may pull the pelvis 盆骨 up towards the ribs or pull the ribs towards the pelvis, depending on which end is "fixed." More than that, in the ordinary physiological use of parts the moving point of a muscle in the upper extremity may be the fixed point of the corresponding muscle in the lower extremity. In contrasting action of the muscles of the hand and foot the use of the terms "origin" and "insertion" may lead to great confusion.

When a cortical area sends forth a volition for performance of a definite movement, the muscles which produce the motion may be designated *prime movers,* e.g. when you bend the wrist, the flexors of the wrist are the prime movers, the origin of the prime movers for this action is in the arm, the insertion is in the hand. Certain laws govern the action of all prime movers:

(*A*) Save in exceptional cases, and then there is only slight movement, an individual muscle does not act alone in response to an act of volition. Movement is the action of muscles working in groups. (i.e. muscles are not represented on the cortex, but movement is).

(*B*) In life a muscle does not necessarily do as a dissected one does.

(*C*) In life, a muscle acting as a prime mover does not necessarily do all the actions its fibres permit in the cadaver. When a muscle can perform several actions it, as a rule, produces one of these in a living subject when acting as a prime mover and its other actions are evoked when it acts other than as a prime mover.

(*D*) When a muscle is capable of producing opposing movements it does not, as a rule, perform these two or more movements when acting as a prime mover in life. It usually produces one as a prime mover and the other when acting other than as a prime mover.

(*E*) A muscle acting as a prime mover will not do its work if gravity will do it instead.

(*F*) A muscle need not act as a whole to perform minimal effort, as more effort is needed more fibres are brought into play, because.

(*G*) Every muscle fibre acts to its utmost and only sufficient fibres are called into action to perform the demanded task.

Prime movers do not act alone; for their stimulation by a volition brings about some change in the muscles which produces the opposite movement. These opposed muscles are then said to act as *antagonists*, 對抗 e.g. the flexors of the wrist are prime movers in a volition to move the wrist towards its palmar aspect, the extensors of the wrist are the antagonists in the action.

Practically every muscle has an antagonist and in action each undergoes changes of some kind. Naturally, when a prime mover contracts, the antagonist relaxes and is moved, but,

A: In ordinary muscle action the relaxation of antagonist muscles is not simply passive inhibition of action for the antagonist function as a controller and regulator of the prime movers. It steadies the part moved and gives precision to the action. The greater the nicety required in the action of a prime mover the more active this antagonistic action becomes.

B: This action of antagonist disappears where opposition to prime movers is great, they then are passive.

C: In unresisted actions in which gravity performs the task of volition, the prime mover ceases to act and the antagonist take a part in the action of paradox, e.g. when we bend the trunk backward we pull upon the spine with the erector spinae muscles, they are the prime movers, but the erector spinae muscles only act up to a point at which the trunk is tilted definitely backwards and gravity would complete the act. The recti muscles of the abdomen are the opponents (antagonists) to the erector spinae, and these relax as erector spinae contract but when gravity takes charge the erector spinae to clase act and the recti begin to contract. They are the only muscles acting and they act to prevent the trunk from toppling backwards. When back bending of the trunk is opposed by an outside force they cease to act and the erector spinae contract again. This is a simple case and in other cases this action of paradox may be very confusing. In the movement of the limbs in which gravity is involved this action must be held in mind.

D: Antagonists like prime movers are called into play in a regular order as the need for action arises.

Synergic 共力 action of muscles: If volition directs a performance of a certain movement and if the muscles called upon to perform it are capable of producing other movements not included in the volition, then other muscles will be called upon to counteract the production of undesired movements, e.g. if we wish to spread the thumb apart from the rest of the digits and pull it as for towards the radial side as possible, we employ the long abducting and extending muscles of the thumb, but those muscles pass over the radial side of wrist joint to reach the thumb their contraction can also pull the whole hand to radial side. This last action is not a part of the volition and if permitted would render the desired action less effective. It is therefore necessary to counteract the action of the prime movers on radial deviation of the hand and for this purpose the muscles which pull the hand to the ulnar side are contracted to keep it steady. The unconscious contraction of these synergic muscles constitutes a part of the neuro-muscular activity necessary for the proper performance of the act of volition.

The above example is easy to follow for, if the flexor and extensor carpi ulnaris be palpated, they will be found to contract every time we abduct the thumb as an active voluntary movement. The laws governing synergic muscles are practically the same as those governing the antagonist.

(*A*) They are not called upon to act when the action of the prime movers is minimal.

(*B*) They are called upon to act in a definite order as the action of the prime movers becomes more powerful.

Fixation 固定 Muscles may also act as fixation muscles, this is often similar to synergic action but it is a distinct and well marked type of muscular action.

If we wish to do an act of precision with the fingers we call into play the prime movers of the action, the antagonists 反抗 exert their regulating control to the utmost, the synergies prevent undesired actions of the prime movers. But as the business becomes more exacting the fixation of the hand becomes necessary, fixation of the elbow may be necessary and when all of our attention is needed for a delicate act which may require but a tiny muscle for its active performance we may, in fact, have to employ a lot of muscles for the immobilization of parts, the movement of which, would hinder the desired act.

One group of fixation muscles is of interest from the point of view of man as a zoological 動物 ype. If one is sitting comfortably in a chair with elbows resting on the arm of the chair, it will be noticed that if the elbows be pressed downwards towards the side, the rectus muscle of the same side of the abdomen at once goes into contraction and that the abdominal muscles and the muscles of the loin harden. A very slight move of arm will evoke a response in muscles from ribs to pelvis. This action (fixation of ribs) is evidently to allow the muscles from the ribs to arms to act to the best advantage.

Here it may be that a co-ordinated muscular action specialised for climbing, as the arm rib muscles are the chief agents for climbing, and it may be a reminiscence of the time when the act of pulling the body upwards towards the arms was one of the functions of the costo-brachial group of muscles. This is a supposition, not a proof of this action.

Most muscles therefore may act; as prime movers, 2. antagonists. 3. synergics. 4. fixation muscles. Every individual muscle is therefore called into play in many more voluntary acts than those usually ascribed to it, when only its prime moving function is taken into consideration. The lower central incisor and the last upper molar tooth engages the biting surface of two other teeth. The loss of one of these is not only a loss of one tooth of thirty-two but it impairs the action of two other teeth. So, the action of muscles. The muscle is not only a contracting agent which produces a definite action. The loss of a muscle is felt not only because its prime moving action is gone, but becausee muscles performing several other actions share in the loss of a member which assist their actions as antagonist, synergic or fixation muscles.

ABNORMAL ACTION OF MUSCLES.

The cortex registers movements and any muscle that can be used in carrying out that motion is called upon to act. If the prime movers of action are paralysed, then any available muscle that can reproduce this action, will be called upon. In this way some unexpected muscles may be trained for action. A patient with paralysis, may educate muscles whose nerve supply is not paralysed, to perform movements very similar to those of the paralysed muscle.

Again this re-education of muscles is exceedingly exacting and one should understand the actions of individual muscles. It may be but cultivation of trick actions of muscles never paralyzed.

THE TENDONS AND TENDON SHEATHS OF THE HAND.

(See Tendons)

The tendons are the fibrous non-contractile tissues developed in connection with contractile muscles whose functions demand other than muscle elasticity and contractibility.

Tendons are developed wherever a muscle changes the direction of its action or takes a turn around some pulley e.g., in the omo-hyoid, the digastric, superior oblique muscle of the eye, and in the tensor palati, etc. They are also present upon adjacent surfaces of muscles wherever much gliding of muscles occurs, e.g. in the vastus externus and soleus. Tendons also occur, as in the biceps, 二頭肌 where it remains tendinous until relieved of pressure of the overlying pectoral 胸的 muscle. They are also present in muscles compounded of multiple morphological elements e.g. in segmental muscles, as the rectus abdominalis 腹直肌, sterno-hyoid 胸舌骨肌, etc.

They may be degenerated parts of muscles which are unimportant. Muscle tendons and fascia represent definite stages of degeneration. The palmaris longus is tending to become less fleshy and to have more tendon than contractile muscle, and its tendon is becoming more or less fascial as it degenerates.

Muscles with much tendon are regarded, generally speaking, as passing into phylogenetic senility. Muscles with much tendon are most difficult to restore to function after injury. Tendons of insertion afford firm union between bone and muscle, yet with the deltoid they are a device for increasing power to the muscle. Also tendons (central) are nature's method of achieving the action of a large number of short fibres instead of a few long ones. In powerful and large muscles arising from several bony points, the tendons serve to concentrate the action of the whole mass of muscle upon one definite point e.g., the triceps of the arm arises from a large area but it is concentrated upon the olecranon by a discrete tendon.

Again a muscle arising from a confined area may need to exert its force over a wide series of bony parts, this is done through multiple tendons e.g. the extensor communis digitorum arises from a simple mass at the radial condyle of the humerus but it is requiredt o act on four digits, and this is done by four tendons. Tendons may therefore be developed either to concentrate or dissipate the action of a contracting muscle. When a fusiform muscle contracts, its two ends are approximated by a shortening of the total length, thus the two bony parts to which it is attached are drawn nearer together, e.g., when the quadratus femoris contracts it pulls the femur directly towards the tuberosity of the ischium 坐骨.

But the action of most muscles is not so simple as that, since, for the most part, in limb muscles, the approximation of bony parts is brought about by angulating the limb at the joints. The muscle simply approximating bony parts is usually a simple mass devoid of tendon except at its attachments. When the muscle action causes angulation of parts and a turn or kink in its axis then the tendon enters largely into the result since the tendon will transmit the pull across the kink or bend.

It is common therefore, in parts where joints (i.e., where kinks or bends occur) are one or more, as in the hand, that the long muscles pass to the parts almost entirely represented by tendons. The tendons on the back and front of the hand show, not only the need to spread out their muscle force upon the fingers but also the fact that the muscles are acting on parts which owing to several joints are constantly bending. The wrist may be bent in two directions, the hand may be bent towards the palm (flexion), or bent towards the kunckles (extension), of these, the flexion is freer and can be carried further. The fingers can be bent towards the palm at three joints, the metacarpo-phalangeal and the two interphalangeal joints, they cannot be bent, in most people, beyond the straight line of extension. The tendons of the flexors and of the extensors are therefore very differently situated in the fingers, for, the extensors merely need to the held steady across the knuckles while the flexors have to be bound down to the joints from which they tend to part company as the muscles contract. At the wrist, both flexors and extensors are subject to the same conditions since both are capable of producing angulation. Herein comes the function of annular ligaments. An annular ligament is a fascial sling which is developed wherever a tendon needs to be bound into place over a joint which is capable of being bent at an angle, therefore, there is an annular ligament over both the flexors and extensors at the wrist, but no such ligament is over the extensor tendons on the dorsum of the fingers because the fingers do not angulate or bend dorsally, therefore, it would not be of use.

Wherever a tendon is retained by a fibrous sling under which it glides, it will have developed around it a special sheath to facilitate the gliding. This is the synovial sheath of the tendon. Each tendon will ran in a tunnel which is surrounded by a fine glistening membrane (synovial membrane), 滑液膜 which secretes a lubricating fluid for the tunnel and tendon. It may be said, as a general rule, that tendons will have synovial sheaths wherever they pass over joints which can be bent at an angle, but tendons that merely straighten parts back from a bent position with no angulation, have not those sheaths.

The retaining ligaments for the flexor extensor tendons are known as the anterior and posterior annular ligaments and are specialized deep fascia. These are natures' wrist bandages.

The posterior annular ligament across the lower ends of the radius and ulna is a tunnelled strap through which the extensor tendons pass. The extensor carpi ulnaris tendon has its own tunnel and sheath. The extensor proprius minimi digiti tendon also has its tunnel and sheath. The extensor proprius digitorum communis and extensor indicis proprius passing over the radius share a common synovial sheath. The extensor pollicis longus has its own tunnel and sheath. The extensor carpi radialis longus and brevis have a common sheath as do the extensor pollicis brevis and extensor ossis metacarpi pollicis. Each of the extensor tunnels is, in part, a bony groove and is, in part, fascial. The synovial sheaths of the extensor tendons are not extensine and they end, above, just beyond the posterior annular ligament; and below, as a rule, at the bases of the metacarpal bones. The sheath of the extensor proprius minimi digiti is commonly carried the farthest on the back of the hand.

The anterior annular ligament bridges over the hollow at the front of the wrists, being attached to the prominences of the trapezium 斜方肌 and scaphoid 舟骨 on the radial side and to the unciform 鈎骨 and pisiform 豌豆骨 on the ulnar side. It forms a roof of specialized deep fascia for a carpal tunnel made by the transverse arch of the carpus and through this tunnel the flexor tendons pass. In the tunnel are two compartments, one for the four tendons of the flexor digitorum sublimis and the two differentiated portions of the flexor digitorum profundus; the other synovial compartment being a sheath for the tendon of the flexor pollicis longus. The tendon of the flexor carpi radialis has its own sheath and also a separate fibrous tunnel on a deeper plane, while the tendon of the flexor carpi ulnaris inserted into the pisiform, has no tunnel and no synovial sheath.

The synovial sheaths or the flexor tendons are far more extensive than those for the extensor tendons under the posterior annular ligament, The synovial space extends above the upper edge of the annular ligament as far as the upper crease line on the lower part of the forearm, whilst below the lower border it spreads out into the palm in an extensive sac called the *palmar bursa*. 掌膜囊 This bursa extends into the hand as far as the middle of the palm. In the case of the index, medius and annularis, the synovial bursa ends at a line at the outstretched thumb.

In the thumb and little finger the metacarpal bones are mobile, the play of the tendons more free and the synovial sheath extends along the tendons without interruption. The flexor tendons do not lie absolutely free within the palmar bursa but are attached to its wall by a fine synovial membrane. There is an almost exact parallel to the suspension of the intestines to the abdominal wall by the *mesentery*. In both cases the functional end is the same, for, the maximum of mobility is attained and, at the same time, a bond maintained for the blood vessels to follow. This synovial sheath of the superficial and deep flexors of the fingers is attached to the radial side of the palmar bursa while the flexor pollicis longus is attached to the ulnar side of the serous space. Although the sacs for the index, medius, and anularis end at the border of the transverse ligament, they again begin as the tendons pass into the fingers. The flexor tendons are bound down to the flexor surfaces of the three joints over which they pass. Ehis is done by a fibrous tunnel which carries the tendons over the three joints. This tunnel is the *thecal sheath* 腱鞘 on theca and is lined by synovia and contains a lubricating fluid. In each thecal sheath, except the thumb, there are two tendons, the deep and superficial flexors. In the thumb, is the single tendon of the flexor pollicis longus which occupies the sheath from the forearm to the terminal phalanx.

Within these sheaths the tendons are again suspended from the deep wall of the sheath to the back of the tendon, these partial suspensions are salled *vincula tendinum* 腱紐 and carry blood vessels. Apart from the binding down of tendons by the thecal sheath, the arrangement of the tendons themselves tends towards this functional result. The flexor sublimus acts as a sling for the profundus and this favours retention during action.

It might seem that for the three joints to be moved, (metacarpophalangeal, proximal distal and interphalangeal) and three muscles to move them (the obsolete palmaris longus, flexor sublimus and flexor profundus) the simplest plan would be for the most superficial muscle to act upon the distal joint and the deepest on the proximal. An opposite plan prevails and the deepest muscle acts on the distal joint. The advantage is, as each tendon is inserted to the proper bone, it forms a retention bond for the tendon passing over to the next bone.

The behavior of the perforated and perforating tendons is most admirably beautiful, efficient, and smooth in working.

Practically, the thecal sheaths form tunnels which, if infected, provide free passage for the inflammation. 炎 In the thumb the tendon ends at the base of the distal phalanx hence infection of the pulp of the finger does not effect the sheath unless it extends to the base of the phalanx. The palmar bursa varies somewhat but, as a rule, it communicates freely with the thecal sheath of the little finger and an inflammation of this finger extending to the base of the terminal phalanx is capable of producing far more mischief than a similar condition of the index, medius and annularis as their sheaths end at the metacarpo-phalangeal joint. It occassionally happens that the flexors of the index, like the flexors of the thumb, have a synovial sheath of their own in the palm of the hand.

When inflammatory processes invade these sheaths and track along them, it is necessary to make free incisions 割口 into the sheaths to permit of thorough drainage.

It is easy to use a knife and make free and easy incision along the middle line of the finger, but there are two disabilities to be borne in mind:—

1. Disability occurs when scar tissue develops at right angles to the normal flexure lines of the fingers, this is important to remember in an organ of such constant use as the finger.

2. If the bonds which normally hold the flexor tendons down in their passage over the joints are severed there will be an entire disablity to the smooth working of this beautiful mechanism. Incisions must be sufficient but not so extensive as to make disability owing to the destruction they have caused. It is a question of applying skill with an anatomical knowledge of the parts so that benefit, not disability, will occur through the surgeons interference.

THE FASCIAS OF THE HAND.

Fascias may be described as tissues of low organization which remain undifferentiated when other structures acquire their definite specializations,

When the muscles are developed in the embryonic limb they are differentiated in the midst of a mass of tissue some of which remains undifferentiated around each specialized muscle mass.

In this way a certain amount of tissue of low specialization is left between the specialized fibres of each individual muscle, around each separate muscle, and around each group of muscles.

This tissue receives different names in different situations; they are all fascia. The tissue between each of the muscle fibres is called endomysium, 肌內衣 that between the collected groups of fibres is called perimysium, 肌束衣 and that around the whole muscle is called epimysium, 肌外衣 this latter is known as the sheath of the muscle and in its extended form, spreading over the whole group of muscles, is called deep fascia. Fascia is left over tissue, between and around the more specialized differentiated tissues it is the packing material of the human body.

The amount of this material differs in different situations, depending on the other structures. In tightly packed organs or structures this packing or fascia is small in amount and only exists as sheaths or fibrous tissue planes. This is well seen in the limbs.

In loosely packed organs, to allow of expansion and contraction in a hollow cavity of the body, packing is abundant and exists as loose strands of tissue occupying spaces between neighbouring organs.

There are fascial planes and fascial spaces, both are important, since exudates or extravasated fluids may track along fascial planes or gravitate into fascial spaces. The fibrous tissue sheaths of all the muscles, tendons, nerves, vessels, bones and joints as well as the general investment of the whole mass of these structures must looked on as an entity, it is all fascia. The functions of these sheaths, etc., vary in accordance with the specialized structures they surround.

In general there are two simple roles fulfilled by all fascial investments. First the blood vessels, lymphatics, and nerves which run to supply an organ are carried to it along the planes of fascia which separate it from neighbouring structures. The fascial planes are the great high ways of the body for the passage of vessels and nerves.

Second, the fascial planes permit of movement of one structureupon another, this is extremely important. As a rule, all structures of the body which are subject to movement are invested in a definite fibrous sheath and usually, the greater the mobility of the part the more perfect is the development of the sheath e.g. compare the parotid gland 腮腺 capsule with that of the pancreas, 膵腺 the former is moved by every movement of the jaw and the latter is relatively immobile.

It is the presence of the fascial investments which makes living stuctures so slippery. It is by reason of these gliding planes of fascia that structures move apart when even very slight pressure is applied to the skin which lies over them. This is particularly seen in the neck where the structures slip and glide readily with slight pressure. This function of fascia is very important and even life saving since it expresses the mechanism whereby pressure on the skin overlying a structure at once causes the structure to dodge aside from points of pressure and avoid injury, often bullets are deflected in this manner and structures lying directly between openings of entrance and exit are uninjured.

In addition to forming planes and permitting mobility, fascia gives rise to definite retention bonds where need for these structures arise.

It may be that in some particular movement of a part some structure is liable to be displaced from its proper position. In such cases, some portion of the fascia will be specially developed to restrain the structure and prevent unwanted displacement. This is usually developed in conection with the play of tendons. There will be instanced another special way in which structures other than tendons are held in place—e.g. the ulnar nerve at the back of the elbow.

Fascia may make pulleys, slings, bands and bridges along which vessels and nerves may pass; and it may form definite compartments in the body, so that movement may be carried on in one compartment without disturbing the contents of other compartments, this is well seen in the hand.

The *deep fascia* 深筋膜 forms a general investment for all the structures of a member e.g., the muscles of the arm, forearm, and hand are all enclosed in a general sleeve of deep fascia which wraps all the structures and holds them in place. It does more than this i.e., merely holding structures in place, for its great physiological function may be likened to an elastic stocking.

The fluids of the body tend to gravitate passively into dependent parts. The muscles are great reservoirs of blood when the limbs are passive, and therefore around all the distensible muscles a firm sleeve of fascia is placed to resist the passive gravitation of fluids. The fascias resist passive fluid pressure, e.g., the thickness and firmness of investing fascia of the leg compared to that of the arm shows the adaptability of the fascia. The more dependent the part in the ordinary position of the body the more complete and strong is the elastic envelope of fascia, e.g. the fascia lata of the thigh.

Superficial fascia is a fat-containing subcutaneous tissue which prevents heat loss from the body and resents a padding of varying thickness for the body.

It is in the superficial fascia that nerves and vessels for the skin ramify on their passage to the surface.

As a rule nerves and vessels pierce the deep fascia as single trunks at discrete openings and subdivision into branches occurs in subcutaneous tissues.

If a superficial vein has to pierce the deep fascia to reach the deeper venous connections, as a rule, the superficial branches join before it passes the deep fascia and, usually an artery or nerve which sends multiple twigs to the skin does so after piercing the deep fascia.

The superficial constitutes a gliding plane which imparts mobility to the skin as deep fascia permits mobility to the deeper tissues. When the superficial fascia is abundant and lax the skin may be freely pulled up and slide upon the deeper tissues. As a rule, the superficial fascia is more lax on the ventral surface of the body than upon the back, and on the flexor than on the extensor surfaces. In one recorded case the skin of the chest could be pulled up over the face. It is owing to the normal differences in structure of superficial fascia, leading to varying degrees of fixity of the skin, that the products of inflammation 炎 developed in the deeper layers of the skin behave so differently in different parts of the body. In dense tissues the inflammatory products may be localized and in lax tissues may spread, e.g., a boil on the back of the neck may be a cellulitis upon the front of the throat.

The septa of the superficial fascia anchors the skin to the deeper structures as is seen in connection with those skin joints of the hand which constitute the palmar crease lines. These are only the manifestation of the normal bands which the superficial fascia form between the skin and deep fascia all over the body.

These bands are arranged in a definite manner in every part of the skin and have been studied in connection with the direction in which a simple wound inflicted by a rounded instrument tends to become elongated.

These bands under normal conditions produce stasis points and skin joints but in old age the loss of elastic tissue in the texture of the superficial fascia and in the deeper layers of skin produces additional stasis lines known as "wrinkles".

Another source of fibrous tissue, classed as fascia, comes from a once specialized structure which has degenerated into fascia. There are in the body fascias derived from degeneration of functionless muscles and from tendons of muscles. These, as a rule, are shining and often have a pearly sheen of blue or green, colour.

The *deep fascia* of the hand forms a dense ensheathing envelope for all the muscles and tendons of the hand.

It is specialized in certain places to form ligaments. It is also continued as partitions among the deeper structures forming sheaths of muscles and tendons. Finally it is joined by the degenerated tendon of the palmaris longus muscle. This layer forms a complete investment of all structures of the hand, back and front alike, a fibrous glove beneath the superficial fascia. The strands of this glove run both round and round the fingers to the hand and also the fabric is woven in different directions.

At the wrist across the heads of the metacarpal bones 掌骨 and in the webs of the fingers the transverse fibres are especially thickened. At the wrist the thickenings keep the tendons in place under the annular ligaments.

The transverse thickening across the heads of the metacarpal bones is the deep fascial expression of the stasis point to which the skin is fixed in flexion of the metacarpophalangeal joints, it is the deep attachment of the moorings of the transverse palmar crease lines, this part has been named the superficial transverse palmar ligament. The transverse fibres of the web are developed especially for the support of this free skin fold and they have been named the ligamentum natatorun, because it is specialized in animals in which the web of the digits is specialized in swimming. In human anatomy they are the interdigital ligaments. From the webs of the fingers this flange of fascia is continued along the sides of each digit as a fibrous septum which joins the skin to the fascia over the sides of the phalanges 指骨 and their joints, upon these lateral flanges the cutaneous ligaments of the fingers (Cleland's skin lig ments) the vessels and nerves of the finger run.

These interdigital ligaments and skin ligaments hamper the full flexion of a single finger when its neighbours are ex-ended. Abnormally developed, they may lessen the free play of the digits. If a finger is permanently bent by injury these ligaments tend to bend the neighbouring fingers.

Of the deep ramifications of the fascia, the muscles of the thumb and little finger are well defined groups and are enclosed in separate fascial envelopes, and thus are separated from the mid-compartment of the hand. These septa are named the internal and exteral intermuscular septa, they pass to the ventral surface of the metacarpal bones of the minimus and medius, dividing the palm of the hand into three separate ventral compartments.

The deep wall of these compartments is formed by the metacarpal bones and by fascia which passes across their ventral surfaces. This fascia is sometimes called the anterior interosseous fascia, a similar layer called the posterior inter-osseous 骨間 fascia exists across the backs of the metacarpals. At the heads cf the metacarpals the anterior interosseous fascia becomes thickened and forms a ligament, the transverse metacarpal ligament. This band passes across four metacar-pals but not to the thumb. In the foot is a corresponding ligament continued right across the sole and fixed to the big toe.

The central portion of the palmar fascia is the part usually referred to when surgeons speak of the palmar fascia. These fibres are a continuation of, or are in continuity, with the tendon of the palmaris longus muscle.

The palmaris longus is a primitive muscle. It is the mostsuperficial of the long finger flexors. Its purpose is to bend the fingers at the metacarpo-phalangeal joint. Three muscles compose the full series of long digital flexors; the palmaris longus, superficial (it flexes the metacarpo-phalangeal joint; the flexor sublinus digitorum intermediate, (it flexes the proximal interphalangeal joints); the flexor profundus digitoum deepest, (it flexes the proximal distal interphalangeal joints).

In man the flexor sublimus 淺 and profundus 深 are retained in full functional form and the palmaris longus exists in 90 out of every 100 persons. But its function is taken over by other muscles and its degenerated tendons are the tendinous fascia which spreads out fan-like over the the palm in five distinct slips, one to each base of each digit. In some animals this muscle has disappeared entirely. In the foot is a well developed plantar fascia but there is no muscle from which it might be the degenerated tendon. The plantaris of the leg is probably not the homologue 類似 of the palmaris longus. These fascial tendons of the palmaris longus may become thickened and contracted and produce a puckering of the tissues of the palm and an obstinate flexion of the fingers (Dupuytren's contracture), and is a sample of pathological processes in degenerated structures. In the palmar fascia on the ulnar side of the hand are somewhat variable muscular fibres which run at right angles to the long axis of the hand and are mostly inserted into the deep surface of the skin over the ulnar border of the hand. These fibres when they contract produce a puckering of the skin and may produce an impression from the base of the little finger to the wrist. This muscle is the palmaris brevis:—

1. it has no homologue in the foot.
2. it is a muscle directly inserted into the skin.
3. it is a muscle apparently with little direct cerebral representation and is therefore not easily activated by the will.

4. it is very easy to stimulate it directly or reflexly e.g., by pressure of the finger-nail upon the wrist just above the pisiform bone. This muscle is absent in all monkeys and anthropoid apes, but is very constant in man. Its purpose is not clearly understood.

JOINTS OF THE HAND.

When the first appearance of the hand condensations, which are the precursors of the future bones takes place in the developing limbs of the embryo, 胚胎 they consist of a mass of cells of undifferentiated mesoblast, 中葉 which is the simple embryonic tissue from which the bones, muscles, the vessels and the fascias are formed.

At first the axial condensation is undifferentiated in the whole length of the limb bud; later on changes occur in certain portions of its length; the simple mesoblast cells become differentiated in definite sites and take on the character of cartilage, the precursor of the future adult bones. In this way a series of short rods of cartilage is developed in the midst of the limb and, around each rod, and between the ends of the rods, there persist the simple tissue from which they were specialised. The mesoblast which remains between the ends of neighbouring cartilages marks the site of the future joint and the fate of this tissue depends entirely upon the demands which the functional use of the part will make upon it.

If free movement is not desired but resilience is necessary, the intervening mesoblast may become changed to cartilage and in the adult condition a wad of cartilage will separate the neighbouring bones. This type of articulation is called a *synchondrosis*, 軟骨結合 and in old age, or when rigidity is no disability, the intervening cartilage may become bone and bone become cemented to bone in a *synostosis*. 骨性接合.

Again where only limited mobility is required but a certain amount of elasticity is essential, then the intervening tissue may develop into specialised fibrous tissue, and the resulting joint is known as a *syndesmosis*. 靱帶聯合 In the hand we do not meet with any joints which conform to these types for here the greatest freedom of movement is demanded of every constituent bone.

When a free range of movement is required in an adult joint a retrogressive change takes place in the intervening mass of mesoblast, for it ceases to be a continuous cell mass and a space—the joint cavity—separates the two neighbouring bones, the original mesoblast forming the thin synovial membrane from which the lubricating synovial fluid is secreted. This type of joint is known as a *diarthrosis* 動關節 and all the joints of the hand are of this variety.

The undifferentiated mesoblast which wrapped around the developing cartilage becomes the *periosteum* 骨外衣 of the adult bones and in the intervals between the bones it passes over the intervening tissue as a tough layer of fibrous tissue called the *capsule of the joint*. 關節囊 This enveloping layer constitutes a complete and continuous sleeve-like investment for the adult bones and joints; it may be called a specialized portion of the deep fascia which is called periosteum around the bones and a capsule around the joints. The great function of the periosteum is that it covers and protects the bones, and serves as a medium in which the blood vessels ramify for the growing bone. *A bone deprived of its periosteum is a bone deprived of its blood supply and the source of its mineral constituents.*

The continuation of the periosteum over the joints (capsule) constitutes a bond between the bones and serves as a confining wall for the synovial space.

In studying any disarthrodial joint attention has to be paid to the articulating surfaces of the bones entering into the joint, to the intervening cavity of the joint and to the capsule of the joint. In a joint of ideal simplicity the two engaging bones do not ossify down to their articulating ends, and the cartilaginous ends of the two bones play upon each other through the intervention of a synovial cavity.

The periosteum of the bone goes from bone to bone over the joint (as capsule) lined by synovial membrane and encloses the synovial fluid. Such a simple articulation is present at the junctions of the ventral ends of the ribs to the sternum, and almost so in the carpus. In most joints there is a modification due to one of the factors viz: —ends of bones, the cavity of the joint, or, the capsule.

The capsule may not be uniformly thick on all aspects of the joint i.e. the stress may develop bands of thicker tissue, in places these are called ligaments e.g. the gleno-humeral 關節盂緣 ligaments of the shoulder. The capsule may be strengthened by fibres from other structures than the capsule, e.g. tendons of muscles, these are also ligaments—e.g. the posterior ligament of Winslow of the knee. Other degenerated structures near a joint may became a part of the capsule e.g. the long lateral ligament of the hinge of the jaw.

Within the joint cavity complications may arise from foldings of the *synovial membrane and in the developemnt of fat in this cavity.* Intracapsular fat is always present when a non-articular part of the bone is within the capsule e.g. a fat pad on the non articular part of the olecranon within the capsule. Fat is found in joints that bear pressure, e.g. hip joint. The shoulder joint is very simple and has no fat. No fat is found in the joints of the wrist or hand.

Another complicating factor re joints, *is the sinking of tendons* into the cavity e.g., the biceps at the shoulder and the popliteus at the knee, or of specialized parts of the capsule as the ligaments in the joints of the hand.

Interarticular fibro-cartilages: **關節間纖維軟骨** there is no common morphology **形態學** for all the structures classed as above. In general they are present to make a more perfect adaptation of the bony surfaces. These may assist in permitting more than one kind of movement in the joint as in the fibro-cartilage of the jaw. It is difficult to explain the necessity of fibro-cartilages. A further specialization is seen in the carpo-metacarpal and other joints. Here the articulating bones ossify completely but the end of each bone is covered with hyaline cartilage which is capable of renewing itself.

The only perfect lubricating machine is found in the human body. It is a joint, because there is a constant thin film of lubricant between the surface—automatically generated.

There are 230 joints in the human body; 25 in each lower limb i.e. 50 bearings are used and oiled with each step; the spine 46; connected with the spine, ribs, breast bone are 84 joints going day and night; there are 4 joints in connection with the head and each upper limb has 23 joints.

When the whole weight of the body is poised on one leg as in every step—the lower and of the tibia presses heavily on the upper surface of the astragalus **距骨** and unless they were lubricated these bones would be consumed.

The mechanism is this: the two opposed bones are covered with thin coats of cartilage. This cartilage is elastic and forms a buffer--its surface is covered with a thin film of synovia which is very slippery like the white of an egg. Joint cartilage is bloodless—not having a single blood vessel or blood corpuscle in it, and yet the cartilage is alive.

The cartilage is studded with living microscopical units which surround themselves with thick soft walls of chondrin. 軟骨素

Cartilage must be supplied with sustenance, and it is supplied by the synovia of the joint and from the thin network of vessels in the bed of the bone beneath it. The villi of the mucous membrane of the joint also probably secrete synovial fluid. The nourishment is the blood plasma. To the naked eye the rubbing surfaces seem smooth but by the microscope there are seen pits in it and these show where cartilage cells have been ground down just as parts of the skin are rubbed off. As the cartilage cell is rubbed off other cells grow in and are rubbed off the substance formed is soft and slippery, and is called the synonia or oil of the joints. The amount of the synovia supplied must be in proportion to the work done in the joint, this is automatic, the more they rub the more oil is secreted. Any excess of lubricant is absorbed by the villi of the mucous membrane and returned to the circulation. Tendon sheathes form lubricant in the same way as joints do.

To return to the hyaline cartilage film, this is developed at that portion where the periosteum becomes continuous with the capsule of the joint. In most of the limb joints this cartilaginous end of the bone becomes highly developed and projects into the cavity of the joint as a cushion which varies in shape with the movements carried out in the adult joint. In such cases the developing bone ossifies up to a line where the periosteum becomes continuous with the capsule as in a less specialized joint but the specialized cushion projects freely into the joint cavity. This cushion is called the *epiphysis* 骺 As growth proceeds ossification commences in the epiphysis but it is separated from the ossification of the shaft (骨幹, of the bone. The epiphysis becomes bone but this bone is surrounded by cartilage: it is covered over its free articulating end with cartilage and between it and the bone there remains a cartilaginous area known as the *epiphysial line*. From this epiphysial line the periosteum leaves the bone to form the capsule, as in simple joints. Epiphyses are therefore separate ossifications developed in joint cavities as specializations of articular cartilages. They may be regarded as *ossa-inter-articulare* which are united to the limb bones by that type of junction known as *synchondrosis*.

The purposes of epiphyses are differently estimated by anatomists. 解剖學家 They are concerned with the growth of bone. When the growth of bone is completed the epiphysis becomes fused with the connected bones and the synchondrosis of union becomes a synostosis — the shaft and epiphysis become an entity and the epiphysial line disappears. The epiphysial line is present during the growth of the bone and when it disappears growth ceases. For this reason it has been thought that the epiphysis is the agent of growth. But the bones of the epiphysis and shaft grow by interstitial calcification 石灰性變 of their cell elements through deposition of calcium salts carried to the growing bone by the blood vessels.

The arteries reach the bone via the periosteum as twigs from arteries or as definite channels which penetrate the bone —*nutrient* 榮養 arteries. So the bone grows in bulk. They grow in length in a similar manner, one end of the bone is usually the site of maximum growth, and at this end more blood is therefore needed, so large *nutrient arteries* are present there. As calcification proceeds, solid bone is formed around the arteries and permanent nutrient foramina 孔 are formed for the vessels which run towards the growing end of the bones. The ends of the bone to which the nutrient artery points are ever growing and extending. The nutrient arteries come from some main artery. The growth of the bone varies with that of the artery, and bones elongate faster than the artery grows in length, so the direction of the artery in the child is towards the epiphysis; in the adult it is away from the epiphysis because the rapid growing bone has increased faster in length than the artery, the artery is carried by the bone and hence its direction is away from the epiphysis. The arteries, in growth, point therefore to the epiphysial end of the bones but in the adult they point away from the epiphysis.

As growth proceeds the cartilage is changed to bone, the bone grows more massive, alters in shape and form, but always the periosteum clothes it *to the cartilaginous end and always the periosteum leaves it at this point to become the capsule of the joint.*

Within the capsule the epiphysis is undergoing ossification, 骨化 but always existing as a neutral zone 帶 between the growing ends of the bone shaft and the growing epiphysis is the epiphyseal line. From this line the periosteum departs to form the capsule. The epiphysial line is therefore *not a line of growth but a line of adjustment.* The ends of the bone grow and the epiphysis and epiphysial line preserve the adaptation of the growing parts and retain harmony in the lines of the bones and joints. The epiphysis is an adjustable pad at the end of a bone which maintains its capacity for readjustment as long as the bones retain their capacity for growth. When the bones cease to grow this line and pad are unnecessary and the epiphysis and bone are welded into one and coalesce.

The epiphysis is developed in and remains in the joint cavity. It is not covered by periosteum or perichondrium as other cartilages are. Its surface is not even covered by synovial membrane which lines the capsule of a joint. Articular cartilage is a naked tissue, it is bare cartilage of one bone playing directly upon bare cartilage of its neighbour.

It is for this reason that erosions of cartilage are so common a feature of joint diseases.

The continuation of the periosteum with the capsule of the joint at the epiphyseal line does not persist in all joints for disturbing factors may cause changes.

To permit freer movement the capsule may become distended and it then folds back over one or both of the articulating ends of the bones. Hence the capsule may appear to be attached some distance beyond the epiphysial line. Thus the "reflected" fibres of the neck of the femur in the hip joint are produced. Again bursae are developed beneath the muscles and may have a secondary connection with the capsule and an enlarged or compound joint cavity produced. The sub quadriceps bursa at the knee is fused with the capsule of the joint and the capsule of the adult appears to arise some distance up the femur. Again the whole of the epiphysis may not be articular and the capsule, as periosteum, may become adherent to the bone between the epiphyseal line and the articulating surface.

In the hand we have the separate joints of the digits, those which exist between individual bones of the carpus, those where the carpus moves on the metacarpals and the articulations of the radius 橈骨 and ulna 尺骨 at their lower ends. The inferior radio-ulner joint is between the fixed ulna and the rotating radius and there supination 旋後 and pronation 旋前 of the hand occur. The capsule of this joint behind and in front passes from the radius to the ulna as a continuation of the periosteum. Between the two bones it is commonly inflated upwards in a pouch called the membrana sacciformis. 囊狀隱窩 This passes up under the lower border of the pronator quadratus. 旋前方肌

The triangular fibro-cartilage has a broader attachment to the radius and a narrower one to the styloid process of the ulna. In an X-ray of the joint there may be a small nodule of cartilage below and lateral to the styloid process, this is a persistence of a cartilaginous mass usually present in the foetus of the second month.

At the radio-carpal joint the hand is moved towards either side as well as in a palmar and dorsal direction.

At the intercarpal joints the mobility is increased by movements between the individual bones. The carpal bones are held together by a common capsule enveloping all of them and passing to the radius and ulna above and metacarpal bones below. The capsule is continuous with the periosteum of all the carpal bones and also the ulna, radius and metacarpal bones. The carpal bones are held together by ligaments within the capsule which divide the synovial spaces, these are *interosseous ligaments*. The carpal bones are strung together by two rows of ligaments which pass transversely. An interosseous ligament passes between the semilunar and scaphoid and between the semilunar and unciform and strings the first row of carpal bones together. The synovial cavity of the radio-carpal joint is cut off from the synovial cavity of the mid-carpal joint. Ligaments unite the trapezium 大多角骨 to the trapezoid 小多角骨 the trapezoid to the os magnum, 頭狀骨 and the os magnum to the unciform, 鈎骨 thus is formed the second row of the carpus, but it does not completely shut off the mid-carpal joints from the carpo-metacarpal joint, for the ligaments between the trapezoid, trapezium and os magnum are fine cords not reaching completely from the dorsal to the palmar surfaces of the capsule. There is only one interosseous ligament (and an occasional and incomplete one) uniting the two rows of the carpus, that between the scaphoid and the radial side of the os magnum.

The pisiform 豌豆骨 is not within the carpal capsule and has its own articulation with the cuneiform. 三角骨

The *Carpo-metacarpal* articulations. The one between the thumb and the trapezium is the most independent and most remarkable. The capsule and synovial cavity are distinct from the other articulations and no interosseous bands join the metacarpal of the thumb to that of the index finger.

The saddle-shaped facet on the trapezium admits of a peculiar mobility, (1) of great freedom of movement because any muscle acting on the joint may avail itself under certain circumstances to produce other than so-called normal movement, this is to be born in mind in cases of muscle paralysis. (2) this peculiar movement is no human speciality. It is known to have occurred in the skeletons of earliest mammals of the Eocene period.

The index metacarpal joint with the trapezoid is peculiar owing to the deep notch in the base of the metacarpal in which the trapezoid is received. The medius metacarpal is firmly implanted in the os magnum and is more stable, through an interosseous ligament which unites the ulnar side of the base with the adjacent surfaces of the os magnum and unciform and their own interosseous ligament. The metacarpals of the annularis and minimus articulate with the unciform by simple cartilage-covered surfaces admitting a fair degree of movement. The metacarpals of the index, medius, annularis, and minimus articulate with each other by the sides of the bases and just beyond this area are bound by interosseous ligaments. The articulation between the metacarpal of the index and medius is one long entire facet. That between the medius and annularis is by two articulating surfaces. A single facet occurs between the annularis and minimus.

The head of the metacarpal bones of the minimus, annularis, medius and index are joined by a transverse metacarpal ligament and are intimately connected with the central capsule of the metacarpal phalangeal joints. At these joints the round heads of the metacarpals—the knuckles—articulate with the concave bases of the proximal phalanges and on both surfaces are epiphyses. The interphalangeal joint has only one articulating surface,—The base of the distal bone is epiphyseal.

The metacarpo—phalangeal and interphalangeal joints are all of one type. Lateral movement is at a minimum in the interphalangeal joints although a certain side to side play exists in the metacarpo-phalangeal joints to assist separation of and drawing together of the fingers. Flexion is admitted to right angles and extension to a straight line. Each joint has a capsule reinforced on the dorsum by an extension of the extensor tendons. The palmar surface is specially thickened behind the flexor tendons and the lateral portions are specialized into definite ligamentous bands. These ligaments pass obliquely from the dorsum behind the head of the bone to the palmar aspect of the base of the bone in front, this is well marked in the metacarpo—phalangeal joints and when these joints are flexed the ligaments are tightened.

The palmar surface of the capsule is complicated in the metacarpo—phalangeal joints where the interphalangeal ligaments blend with the capsule.

The palmar ligaments are specially thickened and are called the glenoid ligaments. These special thickenings are more securely attached to the base of the bone in front than to the head of the bone behind. These are important if the digit be forced backwards and may be torn from the head of the bone if the joint is dislocated

When a dislocation is reduced the torn ligaments sometimes are tucked into the joint between the articulating surfaces of the bones and recurrent dislocations are fairly common for this cause, especially with the thumb.

The glenoid ligaments of certain finger joints are attached to little nodules of cartilages bone called sesamoid bones. 子骨

THE NERVOUS SYSTEM 腦經系統.

This section must be read in connection with the section on ("Hand and Brain"),

The nerve system of man is an apparatus by means of which he appreciates and becomes influenced by impressions from the outer world and hence is enabled to adapt himself to his environment. It is the organic substratum for those manifestations 顯明 of nerve force engaged in the characteristic 性情 attributes of animal life—sensation and motion. It puts the organs into such mutual relation that the animal reacts as a whole with speed, accuracy, and self-advantage, in response to the environmental agencies 動作 which stimulate it.

The nervous system is the most complicated and highly organized of all the various systems which make up the human body. It is built up of nervous and nonnervous tissues. The former of nerve cells and nerve fibres the latter of neuroglia 腦網 and blood vessels with certain embracing membranes.

The central part of an expanded upper portion, the encephalon, or Brain, is contained within the cranium; and a lower elongated cylindrical part, the medulla spinalis, or spinal cord is lodged in the vertebral column, (canal). The two portions are continuous with each other at the level of the upper border of the atlas and together constitute the central nervous system, or cerebrospinal axis.

The peripheral part consists of a series of cerebrospinal nerves which unite the central nervous system to the various parts of the body, and are associated with the functions of the special and general senses, and the voluntary movements of the body.

There are 43 nerves on each side: 12 cerebral attached to the brain, and 31 spinal attached to the medulla spinalis, Three of the cerebral nerves, viz, the olfactory, the optic, and the acoustic are connected with the special sense organs, and they differ somewhat in their arrangement from the central nerves.

ORGIN OF NERVOUS SYSTEM.

The nervous system is all derived from the ectoderm 外胚葉 or outer surface layer of the embryo.

The ectoderm becomes the skin and the nervous system. Thus the skin may be designated as the external nervous system 神經系統 and the brain as the internal skin.

The ectoderm becomes the most external and most internal tissues of the fully developed body.

In the embryo a longitudinal trough on its dorsum 背 is folded in to form a tube inside the body.

The head end of this tube developes the special senses smelling, seeing, hearing and tasting—it grows and becomes the brain.

The ectodermal cells that move into the body become nerve cells. These have very special qualities and have 3 functions—sensitiveness, storage of nervous energy and transmission of that energy.

"In all vertebrates 背椎動物 the central nervous system is fundamentally a hollow dorsal tube in which the primary segmentation is subordinated to the development of important longitudinal correlation tracts and centers. This tube is enlarged at the front end to form the brain. The verterbrate brain may be divided on physiological grounds into two great divisions, first the brain stem, or primary segmental spparatus; and second the cerebellum and cerebral cortex, or suprasegmental spparatus. The brain stem and cerebellum are devoted chiefly to reflex and instinctive activities and constitute the "old brain" of Edinger. The cerebral cortex is devoted to the higher associations and individually acquired activities and is called the "new brain" by Edinger. No nervous impulses can enter the cortex without first passing through the reflex centers of the brain stem.

"In fishes the form of the brain is shaped almost wholly by the development of the reflex centers, and here these mechanisms can best be studied, each of the more obvious parts of the brain being dominated by a single system of sensori-motor reflex circuits. The same pattern is preserved in the human brain, but much distorted by the addition of the centers of higher correlation.

"The terminology of the brain now in most common use is based on its embryological development." (Herrick).

DIVISIONS OF THE NERVOUS SYSTEM.

A. Central nervous system or brain and spinal cord (also called the cerebro-spinal axis).

B. Peripheral nervous system: 週圍神經系統 (1) cranial (2) spinal

C. Sympathetic nervous system—交感神經系統 (really a part of "B." i.e. visceral peripheral system). It is also called the autonomic nervous system. 自主神經系統

The brain and spinal cord are enclosed in the skull and the vertebral column. The peripheral and sympathetic systems are outgrowths of it which serve the central system.

The sympathetic or autonomic systems and the peripheral nervous systems are described separately for convenience but they are coordinated and integrated with the central nervous system.

Nerve tissue is the master tissue. It directs and controls all the activities and movements of all tissues of the body.

Hormones 內泌素 or chemical messengers are carried by the blood from various organs and tissues. This constitutes the endocrine system which by chemical cooperation influences the tissues of the body. The (hormones) are produced under nervous control.

The nervous system directs the performance of all muscles and glands and integrates them into harmonious cooperation and one symphony from birth to death.

The brain and spinal cord do more than direct movements. The anterior or ventral part of these tissues gives orders but the dorsal or posterior part has other and higher functions and superintends and adjust performance to conditions. Life is an adaptation and adjustment of living to environment. Action is adjusted to requirements of the movement.

STRUCTURE OF NERVOUS TISSUE

Nervous tissue consists essentially of (1) *neurons*, 神經單位 held together by (2) *neuroglia* 膠質網 and (3) ingrowths of connective tissue from the *pia mater*. 腦脊軟膜

The *neuron* consists of *nucleus*, 核 *cytoplasm* 細胞質 and *processes*, or, *cell* and *processes*. The nerve cell consists of *nucleus* and *cytoplasm*. They multiply rapidly before birth but *not after birth*. At birth there are 12,000 million of them in the brain alone. *When destroyed in life they are never regenerated*. They live without change and maintain function while life lasts. Memories last for all lifetime.

Nerve cells are enclosed in bone (skull and vertebral column) and are well protected from injury from the outside, however, infection may reach them from within and if destroyed the disability caused is permanent.

These cells vary in size from 1/150,000 to 1/25 inch in diameter. The nucleus presides over and nourishes the processes and is the site of the subtle changes giving rise to a nerve impulse. The processes provide the paths along which the impulse is carried. The processes are called *nerve fibres* and unite into *nerve trunks*. They vary greatly in length. The nucleus is the vital part of the cell—it is essentially different from all other nuclei.

The cytoplasm contains what is called *Nissl substance* 尼氏小體 and fibrils; this substance (Nissl) is rapidly used up during nervous activity and reaccumulates during rest. It is probably the food which, under nuclear control, is stored up and transformed into nervous energy. Speed is characteristic of nerve cells—the activity being almost explosive.

The processes of the cell are usually many and are branched as trees. There may be one or may be hundreds of them. They transmit nervous energy. The neuro-fibrils of the cytoplasm of the cells go into all processes. The processes (dendrites) of the cells go to other nerve cells, one, which carries away nerve impulses from the cell is called the *axon*, 軸 It or branches of it goes to each striped muscle fibre. It is also called the axis cylinder. 神經軸 An axon may be quite short or as long as 3 feet. Dentrites are usually short and convey impulses between cells.—Some dendrites, as sensory impulse conductors from the palm or sole, may be several feet long.

Dendrites not only conduct impulses but are also food carriers. They absorb fluid food from the intercellular spaces. Ten minutes without blood and oxygen causes these cells to die, therefore the importance of dendrites.

Almost all neurons are in the brain and cord. A few original ectodermal sensory cells, olfactory, 嗅 remain in their original surface position. Some neurons are found outside the tube on incoming or sensory nerves. Some neurons move out on certain outgoing or motor nerves and there is a special subdivision for these structure (sympathetic nerve system.) Thus there are great masses of neurons constituting the gray matter of the brain and cord and small groups called *ganglions* outside brain and cord.

In relation to brain and cord neurons are of three kinds; *incoming*, *outgoing* and *intermediate*. *Incoming* are *sensory*. These carry *inwards information* about the exterior and interior of the body. They have long dendrites connecting the outside world with the brain. Their cells are found in the brain or on the ganglions on the roots of incoming nerves.

Outgoing neurons are *Motor*. They carry orders to muscles and glands. They have long axons which are in touch only with gland cells or muscle fibres. Their site in the brain is in front.

In the case of glands and plain muscle fibre of vessels and viscera the cell bodies of the neurons are in sympathetic ganglion. These axons are end pieces as far as the nervous system is concerned—their orders being final but other orders may be sents. *Intermediate* neurons have no contact with the outside they are entirely within the nervous system. Their axons and dendrites are only in touch with other cells of the nervous system. Their function is to deliberate, judge, record and legislate. In them are awareness and decision. Their site is in the dorsal part of the brain and cord and they form great masses.

Incoming and outgoing neurons each communicate at one end with other neurons. Intermediate ones communicate at both ends. Latest research tends to show that it is an electric current, 電流 that flows from cell to cell and from group to group of the definite patterns in the cerebral cortex. Every neuron except the "end" axon goes from one cell to another and forms a close association but no integral union of parts. This communion is called a synapse and there nervous government is carried out.

There is supposed to be some substance or conducting medium between ends or between surfaces of the dendrites 樹狀突 which acts in such a manner that nerve impulses flow from axon to dendrite or from dendrite to dendrite in one direction but not in the opposite direction. Therefore neurons form choices for conduction of nerve impulses in a fixed direction. Different dendrites from a certain cell may go to different receiving cells. This impulse may go to any or all cells, there is a selective choice. There is some resistance at the synapses; it varies from time to time. nervous energy may pass easily or be resisted. There is choice and/or delay at the synapse in response to stimulation.

Fatigue and some poisons and/or drugs (amongst them nicotine and alcohol) may cause a diminution of passage of stimuli.

Dendrites or processes of nerve cells go from every part of the body to the central nervous system. Incoming sensory dendrites extend from their terminal to the brain. Outgoing motor dendrites reach all muscles and through the sympathetic nerves relay all gland cells and plain muscle fibre stimuli. Axons and dendrites of intermediate cells run up and down and across the central nervous system making various and definite communication pathways.

There are as many axons as there are cells and many more dendrites.

All axons and dendrites with their coverings are called nerve fibres. Each process from a sympathetic cell (motor to plain muscle or gland) has one very thin covering. Most fibres within the central nervous system have a thick covering of fatty substance called *Myelin.* 髓鞘質 Most processes extending out from the central nervous system have both the thin and fatty coverings. The myelin looks white. The white matter of the brain and cord consists of fibres without this sheath. The gray matter consists of cells and fibres with sheath.

White matter contains very few blood vessels because the processes are nourished partly from the cells, moreover nervous conduction requires very little energy. Myelin sheath is said to be an insulating material. Nerve fibres are grouped in cables with several cables bound together. The groups of cables are the nerves.

When a nerve fibre is cut across the part separated from the cell dies and is absorbed. The coverings help absorb the remains. The process may grow out again from the cell with the membrane to nourish and guide it. Thus new nerve fibres (with healthy cells) grow new fibres.

Nerves cut by wounds may be resutured. Then the paralyzed muscles and unfeeling skin may months, after suddenly regain sensation and movement. A nerve regrows at the race of about one inch a month. Nerve impulses travel more slowly than electricity—about—4½ miles a minute. It takes 1/100 second for a nervous impulse to travel from the finger to the brain. Electric current travels 186,000 miles per second.

The shape and internal organization of nerve-cells are adapted for rapid metabolism. 新陳代謝 Exhaustion of the cell bodies is marked by visible changes, notably consumption of reserves and disappearance of the chromophilic 易染色性 substance. Nerve-fibers are structurally adapted for conduction and during passage of a nervous impulse their metabolism is increased. They fatigue rapidly, as shown by the refractory phase, but recover their conductivity within a few thousandths of a second. The rate of transmission, varies with the structure of the nerve and its physiological state. In the central nervous system the more complicated structure leads to remarkable changes in the course of events when nervous impulses are discharged into it from the periphery—diffusion, summation, inhibition, and many others. The phenomena of fatigue in the brain are very different from those in the periphery. The higher brain centers are organs of conscious experience, and it has recently been shown that during intense mental work there is a slight increase in metabolism. The nature of the bodily changes which take place in learning, thinking and mental processes in general remains to be discovered.

Summary "Irreversibility.—Though a nerve-fiber may transmit an impulse in either direction, the reflex arc as a whole can transmit in only one direction, that of the normal passage from sense organ to organ of response. The synapse seems to act as a sort of value, to use a crude analogy.

Delay and after-discharge.—The transmission across the synapse involves a delay greater than that of the nerve-fibre. The response of the nerve-fiber begins immediately upon stimulation and does not continue after the stimulus stops. A reflex response may not appear until several seconds after the stimulus and it may persist long after the stimulus has ended.

Fatigue.—The nerve-fiber can be fatigued with difficulty but reflexes fatigue quickly and often are soon completely exhausted.

Action of drugs.—The nerve centers containing synapses and cell bodies are vastly more sensitive to various toxic drugs than are peripheral nerve-fibers.

Metabolic rate.—The gray matter is more richly vascularized than the white matter and its metablolism is more rapid. There is some evidence that regions containing only synaptic junctions have more rapid metabolism than regions containing cell bodies.

Variability.—The nerve impulse transmitted by any particular fiber is, under unchanged physiological conditions, uniformly the same. The reflex arc, on the other hand, is variable in intensity, rate and pattern of response.

Summation, reinforcement and inhibition.—These seem to be effected or facilitated at synaptic junctions.

Rhythm—The relation of rhythm of stimulus to rhythm of response is fixed in the nerve-fiber, but in the reflex there is no such direct relation."

THE BRAIN

The brain is the greatly enlarged upper end of the neural tube 腦管. It is larger in man than in animals and differs in size in different races, decreasing in the following order, Caucasian, Chinese, Malay, Negro and Australian aborigines.

Size—Caucasian 2¾ pints and weight 48 ounces (1,360 gm). It is 2.75% of the weight of the whole body and about 50 times the weight of the spinal cord. In the child at birth it is 13% of the body weight. In small men the proportion of brain to body is higher. In some monkeys and mice the brain weight, in proportion to body weight, is higher than in man. The lowest weight of brain compatible with intelligence in 950 gm. There are great variations in individuals.

Amongst brains of great men taken after death the weight varies from about 2,000 to about 1,350 gm.

The pithecanthropus (Java man) 500,000 years old, is estimated to weigh 850 gm. In the Cro-Magnon race of Europe (50,000 years ago) the estimated weight is the highest general average of all races viz. 1,600. The brains of elephants and whales are heavier than in man.

The mere size of the brain is not a sure index of intelligence. Some very large brains have been found in idiots.— When a child reaches the age of six years its brain has grown approximately to its full adult size. After six years the potential capacity is converted into ability by learning and experience.

The significant difference in the physical structure of brains in men is not size, area, weight or even the number of cells in the cortex *but in the blood supply*. The arrangement of vessels and blood supply as shown by the pia mater shows the driving power of the blood which puts and keeps the brain at work and determines the quality of the work which is performed.

A large brain indicates good growth which is a favourable sign of the ability the individual possesses. Large brains may have no more cells than small ones but if these cells are larger from good blood supply they will, either in small or large sized brains, indicate ability.

The head is composed of the cranium and the face. Each of these parts is the enlarged upper end of the two main tubes of the body—the neural and alimentary tubes. 消化道

The work of the brain is to get information from the outside world hence there we find the special senses of seeing, hearing and smelling. It learns of danger and seeks food. It than orders the body muscles to do its request. The upper and of the alimentary canal is to seize, kill, tear, chew and swallow food. In animals the face and mouth do it all.

The mesoderm gives the protective coverings for the sense organs and leaves channels (e.g. ear) by which sound etc., reach the sensitive surfaces and it forms the membranes to protect the brain. It makes for the face, the jaw and muscles.

The great enlargement of the head end of the neural tube—50 times that of the cord—is explained by the special developments for the sense organs, from which messages go to the brain and are there coordinated. The brain must also know about all parts of the body. The spinal cord receives the information and relays it to the brain.

Thus in the head are developed the nerve centres for sensation, memory, judgment, control and coordination of activities and consciousness. The more advanced the life of the animal the greater the development of the brain especially in its dorsal part. This part is relatively enormous in man and dominates the nerve cell masses below them which control all the engines of the body.

THE PARTS OF THE BRAIN

There are two great enlargements, the cerebrum 大腦 and the cerebellum 小腦, and there are three peduncles or stacks connecting the latter with the mid-brain, 中腦 the pons and the medulla oblongata. 延髓 The internal structure of the brain is very intricate and it has three stages of development (See also-Origin of Nervous Tissue). In the 3 weeks embryo, the brain is shown to be the upper end of the neural tube and it has a large central cavity. The embryo of the second month shows masses of nerve cells or ganglions derived from the neural crest. From them the neurons of the sensory nerves grow outward to the skin or other parts e.g. the internal ear. The retina 視網膜 shows as an extension of the forebrain. In the third month, the two main expansions of the dorsal part of the brain are clearly seen. The more anterior one on each side—the cerebrum—is destined to become enormous and grow dorsalwards and downwards till the right and left masses unite and grow downwards together until they cover all the brain stem and lie in contact with the posterior enlargement the cerebellum.

The human brain in these stages is like the brain of the lower vertebrate animals and it is from this form that the brains of the human adult and higher vertebrate animals have been derived by expansion of parts of their dorsal walls. This relatively simple tube is therefore called the *brain stem* 脳幹 *or old brain* and the great *expansion of the end brain (in man) is called the new brain* (also called neopallium) 新外表. *In the old brain and spinal cord lie the neuron direction of functions that we share with lower animals.* In the new brain is the neuron mechanism concerned in higher activities of human life in which we differ from lower animals e.g. imagination consciousness and intellect.

The six parts of the brain are the end brain (telencephalon) intermediate brain (diencephlon or thalamus), 丘 midbrain (mesencephlon or corpora quadrigemina), is thmus (rhombencephali or peduneulus cerebri) 峽, hind brain (metencepholon or cerebellum) and after brain (myelencephalon or medulla oblongata). These appear in embryos of the first month. A little groove marks off the ventral motor part from the dorsal part. It is called the limiting sulcus 溝. Quite at the upper end of the neural tube is the rhinencephalon or olfactory part. Gradually from this stage the new brain grows in every direction and extends steadily downwards over the brain stem till it overlies the cerebellum as in the adult brain. While it grows, a great tract of fibres grows across from the right side to the left side connecting them close together. This is the corpus callosum 胼胝體,

When the mass on each side has grown big it is called the cerebral hemisphere 大腦半球 and since it grows from the side of the end brain it is always connected with the walls of that structure. The cavity of the neural tube is filled with cerebro-spinal fluid. In the adult the cavity has 4 expansions, called ventricles, one in each cerebral hemisphere, connected on each side with the third ventricle of the interbrain (the thalami), and the fourth is in the hind and after brain. Holes in the roof allow the fluid to pass out and communicate with the fluid which bathes the outer surface of the brain and spinal cord within their membranes. It is this fluid that is withdrawn in spinal puncture. The total amount of it is about 6½ ounces.

The brain stem (old brain) is best seen after the cerebral hemispheres and cerebellum are removed. In the course of evolution of animals the brain stem has grown steadily at its upper end. Below, next to the cord, is the medulla oblongata (after brain) above it is the pons in front and the cerebellum (hind brain) behind. These two parts contain the fourth ventricle.

The three stocks that the cerebellum has, connect it with the medulla, pons and midbrain (mesencephalon). The midbrain has four eminences on its dorsal surface, the corpora quadrigemina 四疊體. The ventral part of the midbrain contains the two great stalks (crus or peduncle) of the end brain. At the upper end is the interbrain (diencephalon) and on each side of it the great masses of nerve tissue called the thalami, each posterior end of which is called the pulvinar 視丘後結節.

Above the brain stem is the end brain (telencephalon) with the olfactory nerves at its tip. Its dorsal surface is enormously expanded into the two cerebral hemispheres. At the base of each hemisphere is the corpus striatum which connects with the thalamus at the upper end of the brain stem.

The brain is made of nerve cells and nerve fibres. The cells are arranged in groups connected by the fibres. These groups of cells are called nuclei and are darker in colour. The white areas are nerve fibre tracts. The cells or gray matter in the cord are placed interiorly, in the cerebral hemispheres and cerebellum their situation is a thin layer of cells spread over the outer surface. This surface is greatly increased in area by the convolutions and the furrows between them and by the in folding of the surface. The total surface is about 352 square inches or 2½ sq. feet. The cortex is about 1/7 inch thick and the cells number 9,000 to 12,000 millions.

Not all of the nerve tracts are fully known. It is difficult to do so since the fibres are only 1/2,000 inch in diameter and may be 3 feet in length. The tracts running between the brain and cord are called "association" fibres and they connect the various parts of the cortex with one another and all other cell masses.

These cells determine our bodily and mental lives. Our characteristics are inherent in brain structure. The animal part of our nature lies in lower levels—the sympathetic, the spinal cord and the lower brain stem. The human part is in the upper brain stem, the corpus striatum 紋狀體, and in the cortex of the cerebrum. Our individual traits are in the cerebral cortex. The upper brain dominates, coordinates, and controls all below it. But they must work through and by information from the lower levels which alone are connected with the body.

We differ from lower animals by the interposition in our brains of masses of intermediate cells. Their interposition between our sensory nerves and other activities gives us fuller and better lives. In animals individuals are more alike and uniform, uniformity is the result of lower centre control, but variability is the keynote of the higher nerve centre direction. The sympathetic system directs the local reflexes controlling digestion and blood supply, these are automatic 自動 and similar in all animals. The spinal cord effects involuntary reflex movements. The medulla oblongata directs more elaborate movements e.g. circulation, respiration and coordinating of body laboratories. The cerebellum adjusts locomotive activities in our positions and movements, receives information of muscular engines and gives vigour and precision. In the midbrain are inherited instincts, social habits and eye and ear reflexes. In the thalamus are general adjustments to ear and especially eye sensations, also a general feeling of discomfort or well being, simple emotions, fear, individual habits and rudiments of learning by experience. In the corpus striatum are complex instincts and the coordination of muscles to bring about general movements. In the cortex are sense of space and time, memory, judgment, consciousness, volition, control of emotions and of the lower centres. The language centre is in the cortex and it contains the apparatus through which we get our sense of social relationships.

The cerebral cortex is essentially the organ of mammals. In the lowest mammals control of intentional movement lies in the corpus striatum but in higher ones it resides in the cortex. So also the apparatus of sensory perception lies there, hence there is greater discrimination because of more cells. Relatively little of the cortex contains motor cells. The sensory part spreads out over the most of this area, so that its wider spread offers more opportunity for more fibers to reach it and thus more separation of anatomical and functional areas. Functional areas are mapped out on the brain surface. These areas merely indicate that injury to them impairs the functions associated with them. Between functional areas are association areas and in these are situated qualities such as recording and judiciary.

All parts of the cortex of both hemispheres are connected in the most intricate away. Cells have more than one fibre and there are 9,000 to 12,000 millions of cells. Nerve impulses of repeated special experiences force themselves along some tracts and structural changes or adaptations occur which leave an enduring record and a tendency to repetition. Cerebral pathways are made more easy by repeated systematic exercises and experience. The cerebral cells become smaller after middle age and the weight of the brain is decreased (about 3% from 40-80 years of age).

The motor area of the cerebral cortex receives fibres from other parts of the cortex and discharges its stimuli into the anterior region of the brain stem and the spinal cord. Thus it controls the motor centres which control all body activity. The motor area makes harmonious cooperation of all body cells. The cortex determines whether we act like animals or thinking human beings.

"Summary—The rhombencephalon 菱形腦 includes the medulla oblongata and cerebellum, that is, all parts of the brain below the isthmus. All of the cranial nerves except the first four pairs connect with the medulla oblongata. An analysis of the functional components of the cranial nerves shows that they can best be understood by considering each functional system of fibers as a unit and studying the connection of each component separately. The medulla oblongata of lower vertebrates and of the human embryo is seen to be composed chiefly of the primary centers related to these functional components of the peripheral nerves, arranged in longitudinal columns in the order, from dorsal to ventral surfaces on each side, of somatic-sensory, visceral-sensory, visceral-motor, somatic-motorcenters. The same arrangement appears in the adult human oblongata, though somewhat distorted by the presence of large masses of correlation tissue and of large conduction tracts which are not present in the lower vertebrates. The sensory centers of the oblongata are connected locally with the adjacent motor centers and also by longer tracts with the spinal cord, cerebellum, and thalamus. The latter fibers constitute the bulbar lemniscus 延腦的蹄係, of which several functional components can be distinguished, the most important being the trigeminal 三叉神經 lemniscus for general cutaneous sensibility, the lateral or acoustic lemniscus for auditory 聽 sensibility and the medial lemniscus for spinal proprioceptive sensibility. The cerebellum is a proprioceptive center developed out of the vestibular area of the medulla oblongata."

The cerebrum contains the primary centers for the I, II, III, and IV pairs of cranial nerves, but most of its substance is concerned with the higher centers for the correlation of sensory impressions, especially those involved in the psychic activities. The midbrain contains in the corpora quadrigeming 四疊體 important reflex correlation centers of sight and hearing, and in the cerebral peduncle centers for the coordination of movements. The diencephalon is devoted chiefly to various types of correlation. It is divided into three parts, the thalamus, 視丘 the epithalamus, 視丘上部 and the hypothalamus, 視丘下部 the two last being dominated by the olfactory system. The thalamus contains a medial group of nuclei concerned with the thalamic reflexes and affective experience and a lateral group of nuclei which discharge the sensory projection fibers of sight, hearing, and general sensibility into the cerebral cortex. The corpus striatum in lower vertebrates is an important reflex center; in man its functions seem to be subsidiary to those of the cerebral cortex for the most part. It consists of two chief masses of gray matter, the caudate 尾狀 and lentiform 豆狀 nuclei, with sheets of white matter between and within these masses. The chief systems of fibers of the white matter are accumulated in the internal capsule which lies between the lentiform nucleus laterally and the caudate nucleus and thalamus medially. Through the internal capsule run the projection fibers which connect the cerebral cortex with the lower parts of the brainstem, including the sensory radiations from the thalamus and the descending systems to the pons and brain stem and the great pyramidal 錐體 tract, which is the voluntary motor path from the cortex to the spinal cord." (Herrick)

FUNCTIONS OF THE CONVOLUTIONS ON THE SURFACE OF THE CEREBRUM.

"The frontal lobe may be conveniently divided into three areas; prefrontal, 額前 midfrontal, 額中 and postfrontal. 額後 The PREFRONTAL AREA embraces all the superior, middle, and inferior frontal convolutions, with the exception of their posterior ends. On the medial side it reaches to the callosomarginal fissure. The function of the prefrontal area is said to be that of higher cerebration, as attention, judgment, and comparison. This region, particularly the lower portion, is liable to injury, owing to its anterior position and to the fact that it overlies the orbit. The roof of the orbit is quite thin and liable to fracture by penetrating bodies, as umbrellas, canes, etc. Sometimes a portion of this part of the brain may be destroyed without marked interference with the mental qualities of the patient. This occurred in the case of a boy who was struck in the eye by a carriage pole (personal observation). The eye was burst, necessitating its removal. Several pieces of the fractured bone of the roof of the orbit were removed and brain tissue came away for several days. The boy recovered and for sixteen years apparently had no resulting mental deficiency.

THE MIDFRONTAL AREA embraces the posterior portion of the superior and middle convolutions, with the upper posterior portion of the inferior. It is concerned in certain movements of the eyes and lids, and also in turning the head toward the opposite side. This midfrontal division is the most anterior portion of what it called the motor area.

MOTOR SPEECH CENTRE, OR BROCA'S CONVOLUTION. 運動的言語中樞 The inferior frontal convolution on the left side is also known as Broca's convolution. Contrary to general opinion, it includes three portions: the part between the inferior precentral sulcus and the anterior ascending ramus of the Sylvian fissure (pars opercularis) 蓋部 the part between the anterior ascending and horizontal rami of the Sylvian fissure (pars triangularis) 三角部, and that between the anterior horizontal ramus and the trunk of the Sylvian fissure (pars orbitalis) 眶部. The motor speech centre or Broca's centre, lies within Broca's convolution and perhaps extends into the adjacent part of the lowest region of the precentral convolution and to the anterior part of the insula.

THE POSTFRONTAL AREA embraces the ascending frontal convolution in front of the fissure of Rolando or central fissure. It is concerned in the various movements of the trunk and extremities, and forms the anterior portion of the Rolandic area; it will be considered under that head.

THE ROLANDIC AREA 運動區. This is the area which gives rise to most of the voluntary movements of the body.

When affected, it causes positive symptoms of paralysis or contration of the muscles connected with it, and is the region most frequently affected by injuries. This is partly due to the fact of its proximity to the middle meningeal artery, as a hemorrhage from that vessel produces a clot which covers and involves this area.

The Rolandic area embraces the ascending frontal, or precentral, and posterior portion of the three frontal convolutions, the former being in front of the fissure of Rolando, or central fissure, and according to the most recent investigations it includes also the paracentral lobule (Fig. 42). The fissure of Rolando passes downward and forward from the longitudinal fissure, at an angle of about 70, nearly to the fissure of Sylvius, being separated from it by the joining of the ascending parietal and ascending frontal convolutions. Sherrington and Grunbaum have shown that the motor area is almost exclusively anterior to the central fissure.

The upper portion of the motor area, near the longitudinal fissure, is concerned with the movements of the toes and lower extremity. The leg centres are toward the upper end of the central fissure; next are those of the abdomen and chest. The arm centres are toward the middle and the face centres, including the larynx, tongue, and platysma myoid muscle, around its lower extremity. The leg, arm, and face centres are, respectively, opposite the posterior extremities of the superior, middle, and inferior frontal convolutions.

The upper portion of the motor area passes over the upper margin of the hemisphere and down on its medial side almost as far as the callosomarginal fissure 扣帶溝 and paracentral lobule.

The Sensory Area. 司覺區 The portions of the cerebrum involved in cutaneous and muscular sensibility embrace the posterior portion of the parietal convolutions, the precuneus or quadrate lobule, and gyrus fornicatus as far forward as the motr area on the medial espect.

THE VISUAL AREA 視區 embrace the occipital lobe, particularly its cuneus lobule, and region of the calcarine fissure on the medial surface of the hemisphere. The anterior portion of the occipital lobe and the region of the angular gyrus are concerned in the more complex phenomens of sight, and their destruction produces word blindness (alexis). Destruction of the centres on both sides produces what has been called mind-blindness, because objects can no longer be recognized.

SENSORY SPEECH CENTRE OR AUDITORY AREA. 司覺的言語中樞 This, the tone-picture or auditory centre is located in the posterior third of the superior temporal convolution and the adjoining portion of the supramarginal convolution. It is also spoken of as Werniche's centre. Here the memory pictures of the heard or spoken words are registered. If it is destroyed, the spoken word will be heard, but it will not be understood. It is the centre of word-deafness or sensory aphasia. The actual centre for the reception of sounds without comprehension is in the middle portion of the superior temporal convolution.

GUSTATORY AREA. 胃區 The sense of taste is supposed to be located on the under and inner surfaces of the temporosphenoidal lobe or fourth temporal convolution. It has not been definitely located but probably adjoins the olfactory area.

OLFACTORY AREA. 嗅區 The centre for smell, or olfactory centre, is located in the anterior portion of the gyrus hippocampi 海馬回 and the hypocampus, on the under portion of the temporosphenoidel lobe.[17]

DAVIS.

MOTOR (EFFECTOR) NERVES.

From the anterior part of the cord and brain axons grow out to the whole body. These are motor nerves and may or may not be associated with sensory axons in a nerve.

These motor nerves are found in the ventral roots of the 31 pairs of spinal nerves and in all the 12 cranial nerves except first, second and eighth (olfactory, 嗅 optic, 視 and auditory 聽). The 11th and 12th cranial (accessory 副, hypoglossal 舌下 are entirely motor.

The ventral neurons have their cell bodies inside the brain and cord; the sensory neurons have their cells in ganglions outside the brain and cord.

The motor or effector nerves carry impulses from the brain to the 3 kinds of muscles and to the glands and these four agencies produce all our activities.

The muscle cells are very numerous e. g. in the sartorious 縫匠肌 there are about 140,000 cells.

There are several billions of cells in striped muscles of the whole body, millions to smooth muscle in the intestines, blood vessels and viscera, and thousands to the muscle (special striped) of the heart.

Activities of these structures are harmonious because the nerve stimuli to them are harmonious. The processes of motor cells grow from groups of cells in the gray matter of the brain and cord. In the brain stem such motor cell groups are called *nuclei*. All of these are situated ventrally i. e. anteriorly Some are nearer the mid line than are others. Nerves to the eye muscles, oculomotor 動眼 (third), trochlear 滑車 (fourth), abducent 外展 (sixth) and hypoglossal 舌 (12th) are closer to the midline than those for nerves and glands of the head part of the alimentary canal trigeminal 三叉 (5th), facial 面 (7th), glosso-pharyngeal 舌咽 (9th), vagus 迷走 (10th), and accessory 副 (11th).

In the spinal cord the cells for visceral muscles are in the lateral part of the anterior horn of the gray matter while those for the skeletal muscles are nearer the midline.

The visceral and circulatory muscles are made of smooth muscle fibres. Most glands lie in the intestines or skin. The mind has little control over these. Smooth muscle and glands are concerned with slow vegetative actions, e.g. digestion and circulation which go on essentially alike in all animals. This action is an inherited automatic action pattern which goes on unconsciously and it is regulated by the laterally placed cells.

Skeletal muscles act quickly and are conscious of motions produced. These intentional motions vary greatly according to times, environment and individual traits. The cells governing these two kinds of action are in different positions in the brain and cord. Besides differance in position of these sets of cells there is a greater difference in their nervous control. The automatic action of viscera, glands and vessels is subject to little direct control by the brain and cord but is controlled by a subdivision of the nervous system called the sympathetic or automatic or autonomic nervous system because of its relative independance.

NEURONE THEORY.

Cunningham p. 512

"Neurone" is the term applied to a nerve-cell and all its processes and the neurone doctrine assumes that there is no continuity whatever between the substance of one neurone and that of another, such as occurs in Hydra (Fig. 421), and that the functional connexions between them are brought about merely by the contact of the proceeses of one element with the processes, or the cell-body itself, of another element.

In accordance with this conception the facts of embryology are supposed (by his) to demonstrate that when the axon grows out from a previously spherical and unattached cell it is able to push into the surrounding tissues, and, as it were guided by some instinct, eventually finds its way to that particular area of skin, muscle, gland, or other part of the body where nature intends it to go.

The difficulty involved in such a conception is not only that it is opposed to all that is known of the early stages in the evolution of the nervous system, but also that it is difficult to conceive that every one of the millions of nerve-cells, muscle-cells, visceral and cutaneous elements can each have some specific attractive power which leads every individual nerve fibril to its appropriate and predestined place in the body.

SENSORY NEURONS 知覺神經單位 SENSE RECEIVERS.

Knowledge of ones environment is essential to all animals. This is obtained by and through certain cells specially sensitised to material things. Things give off particles in the air—some of which we smell. Things go into our mouths, go into solution and we taste. Things vibrate, this may cause enormous effect on our bodies, they may help or kill us. We have sensory cells especially for these vibrations, (hearing).

Human limits to the senses are often less than in animals, e.g. dogs and their sense of smell. Of vibrations of the ether, humans have a limited range and only near the centre of the scale, e.g. heat and light. Vibrations as used in wireless telegraphy and in radio are too low for human senses; while above our range are ultra-violet rays, and X-rays and radium emanations. We sense but part of our environment--probably the lesser part. Many energies go on which we do not know. Some insects and animals have sense cells the nature of which we do not know.

Our sensory cells are delicate and efficient within our range. Our eyes detect the light of the stars which are incredible distance away—very little energy must reach us from these stars. That part of the world to which we reach, is determined by our sensory cells—*our* world not *the* world. Much we do not know, eyes, ears, sight and nose are insufficient. All information the central nervous system receives is due to the effect of stimulation of our sensory nerves. These nerves extend from the surface of the body and its parts to the brain and cord.

Nerve trunks are only 86 in number—12 pair to the brain and 31 pairs to the spinal cord, but their branches are innumerable.

The nervous centres are served by all the senses of the body. The recording, guiding, deliberative and judicial departments of the nervous system are situated in the dorsal part of the brain. Sensations enter, are analysed, directed translated into action there.

Only in the dorsal brain is consciousness or mind. There sensations are checked and impulses and responses are coordinated, inhibited or released. The dorsal brain organises and selects pictures of conduct (action pictures or patterns). Sensation, memory, contemplation, judgement, decision and direction are functions of the automatic nerve tissues stimulated by environment.

All sensory nerves except the olfactory grow out in embryonic life from the neural crest. The neural crest has a right and left connection with the skin. The cells composing them become masses and form the dorsal root ganglia. Some cells send branches into the neural tube and other branches spread through the body. Their terminals are sensitive to stimuli of specific kinds. Those near the surface get information from the outside world and those that go to the interior of the body to the muscles and viscera get information from those sources.

Each sensory nerve has a root in the dorsal part of the brain or cord and has on it a ganglion. These ganglion cells are the life centers of the sensory neurons. Their processes carry nerve impulses. From sensory nerve endings they go into the cord and are connected with other neurons.

Of the 42 pairs of nerve trunks 12 come from the brain, viz: the olfactory, optic, oculomotor, trochlear, trigeminal, abducent, facial, auditory, glossopharyngeal, vagus, accessory hypoglossal. The first, second and eighth are sensory, the eleventh and twelveth are wholly efferent (outgoing). The others have both incoming and outgoing fibres.

Thirty-one pairs of nerves go off from the spinal cord, 8 cervical, 頸 12 thoracic, 胸 5 lumbar, 腰 5 sacral 骶 and 1 coccygeal 尾. Each has a dorsal and ventral root on each side, the former is sensory the latter is motor. These go off separately but unite to form a "mixed" nerve.

The 10 cranial nerves that carry sensory fibres to the brain go to certain parts.

The olfactory nerve remains in the skin which dips into the nasal pit. They are true nerve cells and are the only ones which remain on the body surface. Each cell has a tiny process terminating in a vesicle with a cilia on it. These vesicles and cilia are moist in the nasal fossa and are chemically sensitive and are receptors of smell. One process of the cell goes to olfactory bulk in the brain. From this bulk a tract of fibres goes to the forebrain.

"The olfactory centers (rhinencephalon) make up nearly the entire forebrain in fishes, and in higher vertebrates progressively more non-olfactory centers are added to this part of the brain. The non-olfactory parts of the cerebral hemisphere comprise chiefly the corpus striatum and the neopallium; the latter makes up by far the larger part of the human hemisphere. The rhinencephalon consists of a reflex part in the brain stem and a cortical part in the archipallium. Smell and taste are both chemically excited senses, but the threshold of excitation is much lower in the case of smell. This is brought about by the suppression of a synapse in the peripheral receptor organ and by a complex mechanism for the summation and reinforcement of stimuli in the primary olfactory center in the olfactory bulb. The secondary olfactory center is the olfactory area, which has three parts, each of which is a reflex center of distinctive type. The reflex path from the secondary center passes backward to the epithalamus and to the hypothalamus, from each of which a descending path goes to the motor center also discharges into the olfactory cerebral cortex, which is chiefly contained within the hippocampus and from which manifold association pathways connect with all other parts of the cerebral cortex." (Herrick)

Optic nerves are within the eyeball and their innermost alayer are called the retina. The retina is an outgrowth of the forebrain and remains connected with it and the midbrains With an ophthalmoscope 檢眼鏡 the doctor looking at the retina, sees the brain and gets information. The eyeballs are like 2 cameras about the retina. These cameras are adjusted by muscles. The pupil is a hole in the diaphragm and is regulated by light. The retina contains "rods and cones", there are about 130 millions of rods and 7 millions of cones. The rods contain a chemical substance which bleaches with bleaches with light—thus photographing occurs. From the retina fibres pass to the intermediate and midbrain.

"The retina is developed as a lateral outgrowth from the early neural tube and throughout life retains its character as a part of the brain, the "optic nerve" being really a correlation tract comparable with the lemniscus systems. The rods and cones of the retina are the photoreceptors and also the neurons of the first order in the optic path. The "optic nerve" contains neurons of the third order from the retina to the thalamus and midbrain, and also centrifugal fibers from the midbrain to the retina. In lower vertebrates the fibers of the optic path decussate completely in the optic chiasma, but in those mammals whose fields of vision overlap there is an incomplete decussation so as to ensure the representation of the field of vision of one side completely in the opposite cerebral hemisphere. Those fibers of the optic tract which terminate in the midbrain effect various kinds of reflex connections, while those which terminate in the thalamus effect cortical connections. The parietal or pineal eye of some fishes and reptiles is apparently functional as an organ of vision which was developed quite independently of the lateral eyes." (Herrick)

Auditory 聽 nerves lead from the inner ear to the hind-brain. In the inner ear they are exposed to air vibrations which produce sound. The nerve terminals connect with cells bearing cilia. Over 15,000 of these cells are in each ear and by means of these we detect tones. The nerve cells of these nerves form a ganglion in the axis of the cochlea. The cochlea is shaped like a snail shell. A canal runs spirally around its axis 2½ turns. This canal is full of fluid and contains the auditory nerve terminals. Thus the vibrations are in fluid not air. The air vibrations produce fluid vibrations.

The auditory nerve also contains fibres which are not concerned with hearing. Some of these come from 3 delicate membranous semi-circular canals. This apparatus gives us the *sense of movement in space*. These canals are in three planes, one horizontal and two vertical at right angles to each other. The canals are filled with fluid and each contains at one end an enlarged ampulla in which is a solid mass called cupula lying in the fluid. The nerve terminals are little hair like processes which project into the cupula. In movement the cupula lags behind and pulls on the hairs and gives a sense of the direction of movement.

"The vestibular apparatus and the cerebellum are genetically and physiologically very closely related. The semicircular canals 半規管 are the most highly differentiated proprioceptive end-organs, serving chiefly the functions of equilibration and the maintenance of muscular tone. These reactions are, for the most part, unconsciously preformed and there is no important cortical path from the vestibular nuclei. These nuclei effect reflex connections with the motor centers of the spinal cord and medulla oblongata, especially the eye-muscle nuclei, and with the cerebellum."

"The cerebellum has been developed out of the primary vestibular area for the more perfect coordination and integration of the somatic motor reaction and for strengthening these reactions. It receives afferent fibers from all somatic sensory centers, and in mammals it is also very intimately connected with the cerebral cortex, these two higher centers appearing always to act conjointly. The cerebellum discharges into all of the somatic motor centers and assists in preserving the proper balance of muscular contraction and in the maintenance of muscular tone." (Herrick)

Other fibres of the auditory nerve come from the utricle which is close to the semicircular canals. It is full of liquid and contains stony particles called ear stones or otoliths. This gives us a *sense of position* when the head and the rest of the body is still. The otoliths tend to sink to the lowest level in fluid. Hair like nerve terminals are on the walls of the sack and so in different positions the otoliths touch and stimulate different terminals and thus we get our sense of position.

The nerves to these sense organs are incorporated for some distance with the auditory nerves. The ganglions on them are enclosed in the temporal bone and they carry their sensory impulses along with the auditory impulses into the dorsal part of the hindbrain or cerebellum.

Another sense closely associated with these is that of skelital muscles. We sense unconsiously the effect being made with muscles. Nerves to muscles composed of striped fibres have in general 40% of sensory fibres in them and we are able to modify and coordinate our muscle action with amazing delicacy. Even standing requires constant adjustment of muscle action in response to sensations of pressure or position.

The nerve terminals for muscle sensation are in the muscle spindles. Some tiny muscle fibre terminals are grouped in spindle shaped masses along the larger fibres. These have the sensory nerve terminals. When the larger fibres contract the little ones also contract and the little ones report to brain what the larger ones are doing. All the dorsal roots of spinal nerves carry in muscle sense, as also do the 3rd, 4th, 5th, 6th, 7th, 9th and 10th cranial nerves. The nerves go into the dorsal part of the cord and brain and the impulses are relayed by other fibres to the cerebellum. Along with these are sensations of position and movement.

The cerebellum is the great correlator of muscle activity and movement in space. The cerebellum has no consciousness whatever so the senses reported to it carry intelligence *without conscious recognition.*

Sensations of taste are carried on by the seventh nerve from the anterior part of the tongue, by the ninth nerve from its posterior part and the tenth from the epiglottis. The cells concerned are not nerve cells but specialized cells of the lining of the foregut or entoderm. These are taste buds on the tongue and pharynx. They are dome shaped cells with taste buds inside with terminal hairs projecting from the apices of the buds. These are chemically stimulated by substances in solution. They only distinguish sweet, sour, salt and bitter tastes. (See Summary under sympathetic system).

Sensory nerve terminals are very highly specalized. Each is exquisitely sensitive to a particular stimulus and no other, e.g. no amount of light will stimulate a taste bud.

Most of their nerves lead from terminals that are stimulated by touch. The sensations resulting are of many kinds and may be conscious or unconscious. Many varieties of terminals may be associated with one nerve. There are touch corpuscles for light and deep pressure, there are others about hairs, others for lining of the mouth, others for sensitiveness for cold and heat, others for pain etc. Many terminals are found in the viscera. Of these we are not conscious in health. Special nerve terminals are related to hirst, hunger nausea, and emotional sensations.

These sensations all stream into the dorsal part of the central nervous system. Some go directly to the brain, others to the cord where they connect with another neuron and are relayed to the brain. In the brain they are combined. The brain knows all. It receives millions of stimuli. All sensations go to it.

"We have seen that the chief function of the sense organs is to lower the threshold of excitability of the body in definite places to particular kinds of stimulation, and thus to effect an analysis of the forces of nature so far as these concern the welfare of the body. The nature of this analysis of the environing energy complex was illustrated by a review of the ways in which the body may respond to different kinds of vibrations. The senses, as this word is commonly used, were distinguished by four criteria, termed briefly the psychological, physical, anatomical, and physiological (Herrick)".

SYMPATHETIC OR AUTONOMIC SYSTEM

(See under Hand and Brain)

The nerve cells of this system wander out from the cord and brain along the motor nerves during early embryonic life to a position nearer the intestines.

Some group themselves near the vertebral column on each side in a gangliated chain; others go farther inward and form ganglions near the aorta; also there are the solar, renal and other plexuses. Some are found in the walls of the heart and intestines.

The cells directly controlling plain muscle fibre, heart muscle and glands are widely scattered. They direct the activities of the intestine uterus, spleen, kidneys, bladder and other viscera with plain muscle or glands. They regulate the circulation of blood and lymph. They also regulate the sweat glands of the skin and the muscles which make hair stand up. All this regulation is largely automatic.

There are 3 main groups of these cells; the gangliated cord, the plexuses of the aorta and in the walls of the viscera. This cord usually contains 26 ganglions on each side, 4 in the head, 3 in the neck, eleven in the thorax, 4 in the abdomen and 4 in the pelvis. The lowest pelvic ganglion is an apex where both cords meet. These chains of ganglions are the centre of the sympathetic system. From them fibres go to the plexuses and viscera, to each of the spinal nerves, and to the 3rd, 5th, 7th, 9th, and 10th cranial nerves.

The sympathetic system is largely automatic, and is subject to some interference by the cord and brain e.g. our thinking can disturb our digestion. Some parasympathetic fibres go direct to viscera from the brain.

Intermediate Cells

Sensory and motor neurons are not by themselves enough to adjust the life of any animal to its surroundings. There must be intermediate cells. The sensory stimuli may pass directly to a motor neuron but even so intermediate cells are stimulated.

The action resulting from the transmission of a nervous impulse from a sensory neuron to a motor neuron is called a reflex. Reflex action is typical of nervous tissue. Such action always involves some or many intermediate cells. Without intermediate cells animals could not react as a whole and all animals so react. There is no such thing as a simple reflex act i. e. one sensory neuron connecting directly and exclusively with a motor neuron.

The intermediate cells modify the reflex act. There are 12000 million cells in the human brain and most of them are intermediate cells. These are interposed between the sensory and motor neurons. They are deeply placed in the body and sheltered from casual irritation. They have no processes extending out to the surface or to muscles or glands. They are all linked up with one another into one connected system receiving all incoming sensory impulses and give off all cues for execution.

The passage of a nervous reflex through such a system causes modification of it. The stimulus produces a reaction in the whole body and thus the intermediate cells integrate and intensify the reflex by coordinating many cells with much greater force on the muscle or gland involved. These intermediate cells combine the sensory stimuli from many sensory cells and permit reaction according to the sum of all stimuli received. They may augment, delay or prevent completion of the reflex and thus complete complex movements. They preserve memory and some of the cells may acquire consciousness. Thus memory, judgment and intelligence are developed.

"Summary.—Viscera are defined as all organs concerned primarily with the maintenance and reproduction of the body as contrasted with somatic organs concerned primarily with adjustments of the body in relation with its environment. The visceral nervous system includes all neurons, central or peripheral, primarily concerned with control of the functions of the viscera. The visceral and somatic nervous systems are intimately related both centrally and peripherally, for most bodily functions involve the cooperation of somatic and visceral organs. The visceral nervous system includes a special part confined to head and wholly unrelated with the sympathetic system, and a general part always distributed through the sympathetic system. The sympathetic nervous system as here defined is that part of the peripheral general visceral nervous system which can be separated by gross dissection from the cranio-spinal system, as by cutting the rami communicantes. This is the original anatomical usage, whose value rests only on descriptive convenience. Fibers of the general visceral nervous system cross the artificial boundary between cranio-spinal and sympathetic systems in the rami communicantes. The sympathetic system includes the ganglionated trunks bordering the spinal column, the larger peripheral ganglionated plexuses of the head, thorax and abdomen, and a very large number of minute sympathetic ganglia scattered everywhere throughout the body. The sympathetic nervous system we regard as composed of two imperfectly separable parts: (1) a series of autonomous peripheral ganglia for the local regulation of the organs within which they are found; (2) the neurons of the cranio-spinal visceral systems which enable the central nervous system to maintain a regulatory control over the viscera, either directly or through the intrinsic autonomous systems."

"The cranio-spinal visceral systems fall into a general group related peripherally to the sympathetic nerves and a special group independent of the sympathetic. The second group includes the apparatus for taste and in part for smell. The central innervation of the viscera is partly from the spinal and midbrain regions, but chiefly from the visceral area of the medulla oblongata. The heart and blood-vessels have a double innervation derived from both the spinal and the bulbar visceral centers, and the nervous control of the organs of circulation is very complex. Respiration in lower vertebrates is effected by strictly visceral structures and is controlled from the visceral area of the medulla oblongata. In mammals the muscles of ordinary respiration are all of the somatic type, but the centers of control are retained in the visceral area of the oblongata. 延髓 The sensations related to the digestive tract are served chiefly (though not exclusively) by the vagus. There are special salivatory nuclei related to the VII and IX cranial nerves. The nerves of taste are the VII, IX, and to a very limited extent (in man) the X pairs of cranial nerves. The primary cerebral gustatory center is in the upper part of the nucleus of the fasciculus solitarius, but the cortical path is unknown.

"The general somatic systems include the sensorimotor apparatus of cutaneous and deep sensibility and the innervation of the skeletal musculature. The exteroceptive systems (touch, temperature and pain) have different end-organs and cerebral centers from the proprioceptive systems. In lower vertebrates this distinction is not so sharply drawn, and even in man they are not wholly distinct centrally. The exteroceptive systems are transmitted from the spinal cord to the brain through a complex tract, the spinal lemniscus, 蹄係 within which there are separate pathways for the three qualities of sensation, touch, temperature, and pain. These sensation qualities come into consciousness with a distinct pheriphertal 週圍 or external reference. The proprioceptive systems (muscle sense and allied types) are transmitted to the brain through the dorsal funiculus of the same side of the cord, the medial lemniscus of the opposite side the thalamus, and the somesthetic radiations to the cerebral cortex; and also through the spinocerbellar tracts to the cerebellar cortex. Most of these reactions of spatial adjustment do not come into consciousness at all, but some appear subjectively as sensations of posture, bodily movement, and spatial discrimination. The cerebellum is the great clearing house for these and all other afferent systems which are concerned in the proprioceptive functions, so far as these are unconsciously performed. Cutaneous and deep sensibility appear in two forms termed by Head protopathic and epicritic and by Stopford protective and discriminative. These types apparently are not served by distinct end-organs and nerves; the distinction is centrally, not peripherally, determined. Protopathic types are primitive forms of sensibility related with the brain-stem; epicritic types "are those which have been proved to have cortical representation." (Herrick)

THE SPINAL CORD.

Sensory and sympathetic nerve cells lie as a rule outside the neural tube of the embryo, and as derived from the two ectodermal crests. Many motor cells wander out at a later time. The neural tube lies between the sensory and motor neurons and is composed mostly of intermediate cells.

The larger anterior part of the neural tube becomes the brain and the rest of it the spinal cord. The two together constitute the spinal cord. Into the dorsal part of these structures extend the sensory nerve fibres which bring information from its ventral part. Fibres go directly to the muscles and indirectly through the sympathetic system to the smooth muscle fibres and the glands.

The spinal cord is about 18 inches long in the fully developed adult. It weighs less than an ounce. It is shorter than the vertebral canal. At the third month of uterine life it is as long as the column but at birth its lower end is on a level with the third lumbar vertebra. In the adult it barely reaches the second lumbar and in a tall man it may not extended below the last rib.

The cord terminates in a horse—tail arrangement called the cauda equinus. 馬尾 The roots of the lower ten pairs of spinal nerves, 40 in number, extend downwards in the long glove-like dura mater which encloses the cord and contains the spinal fluid which acts as a water cushion to protect the cord and nerves from shock.

Some of the spinal fluid is frequently drawn off for diagnostic and treatment purposes. This is done by inserting a hollow needle into the dura mater below the cord. This is called lumbar puncture. Neither the cord or nerves are injured for the needle enters a fluid filled canal below the cord proper.

The pia mater 軟膜 is a delicate membrane carrying the arteries and veins for the cords' supply. The central grey matter of the cord receives more blood than the white portion of the cord. The former contains cells and the later the fibres from the cells.

The nerve cells are massed in the central column in an H-shaped manner. In cross section there are shown 2 anterior and 2 posterior horns of this gray matter. The posterior horn contains intermediate cells which have sensory connections. The anterior horns contain motor cells for the striated muscles of the limbs and trunk. *These are the site of infection and inflammation in infantile paralysis.* Between the anterior and posterior horns the gray matter at the sides of thecentral canal of the cord contains intermediate cells which are connected through the sympathetic system with blood and lymph vessels and with the viscera.

The white matter of the cord surrounds its central gray canal. It consists of nerve fibres entering, leaving or passing up and down within the cord. The entering fibres are sensory nerves entering the posterior horn, The outgoing nerve fibres go through the anterior roots. The fibres passing up and down connect sections of the cord with each other and the brain.

The outgoing (motor) fibres do not go out in a continuous series but in 3 groups: an upper group in the neck from the brain, a middle group in the thoracic region and a lower sacral group. No nerves go to the sympathetic chain from the cervical and lumbo—sacral regions. 骶腰部 But the thoracic group sends fibres to the gangliated sympathetic trunk and to all viscera and vessels.

These cranial and sacral fibres are called parasympathetic to distingush them from the thoracic group. They go to the viscera and to vessels which thus have both a sympathetic and parasympathetic 副交感 innervation. Their actions are often directly opposed; one causing activity and the other checking activity of glands and smooth muscle. This control is easily and evenly balanced so that vessels and viscera delicately and promptly change according to changing conditions of the body.

The entering sensory fibres pass up and down the cord and connect different segments—thus a chance for extensive reflex action. Other fibres passing up and down the cord are wholly within the central nervous system. They are relay fibres carrying both sensory (in) and motor (out) impulses. These are grouped in bundles and are connected with certain groups of cells at both ends of the bundle. Each remains in its own place in the cord and has its own special functions. Disease of one part of the nervous system can be detected through disturbance of function of any particular bundle. The position of the bundles should be known.

Many fibres cross over from side to side in the cord, thus bringing both sides into close cooperation. The motor fibres that descend from the brain to the cord nearly all pass over before they terminate in synapses with the cells of the anterior horn. The right side of the brain controls the muscles of the left side of the body; and the left side controls the muscles of the right side of the body. Righthandedness is associated with left-brainedness. Injury of the left side of the brain (e.g. cerebral haemorrhage 流血) produces paralysis of the right side of the body.

The right side of the average man is heavier than the left and the left half of the brain is slightly heavier than the right.

Right, or, left—handedness are associated with this crossing of fibres and there goes with it one-sidedness of some of the higher functions of the brain e.g. speech control is on the right side of the brain in right-handed people and on the left side in left-handed people. Thus in forcing a child to change from left to right-handedness there sometimes results stammering or other speech defects.

"The spinal nerves are segmentally arranged and are named after the vertebra adjacent to which they emerge from the spinal canl of the vertebral column. Each nerve arises by a series of dorsal rootlets afferent in function and a series of ventral rootlets efferent in function. Most of the gray matter of the spinal cord is massed in two longitudinal columns on each side, for somatic sensory and somatic motor functions respectively. These are separated by an intermediate region containing the visceral sensory and motor centers and various correlation neurons. The white matter of the cord is superficial to the gray and contains myelinated fibers for various kinds of correlation, besides root-fibers of the spinal nerves. The white matter is divided topographically into funiculi 索 and fasciculi 束 and physiologically into tracts. The latter are the really significant units in the analysis of the cord. Peripherally, the spinal nerves divide into deep and superficial branches, and each of these contains various functional systems of fibers. As soon as the peripheral nerve-fibers have entered into the spinal cord they are segregated into proprioceptive and exteroceptive groups, and each of these again into particular functional tracts. There are connections for local spinal reflexes, reflexes of the brain stem and cerebellum, and for the cerebral cortex. The spino-cerebeller tracts and the dorsal funiculi are proprioceptive in function, and the spinal lemniscus 蹄係 carries spino-thalamic tracts of the systems of touch, temperature, and pain sensibility for the cerebral cortex." (Herrick)

SKELETON.

(See "Joints of the Hand".)

The *Skeleton includes bones cartilages, ligaments and joints.* Bones are the most durable parts of the animal body. Fragments of skulls and other bones have been found e. g. the "Java" and "Heidleberg" remnants; the "Piltdown" Skull remains, and, the "Peking" Man. All of these are extremely ancient the youngest of them probably is more than 500,000 years old.

The skeleton supports the body; it protects the brain, the viscera of the thorax and pelvis; and cooperates with the muscles. Most muscles are attached to the skeleton and these with joints, together constitute the locomotive apparatus whereby movement is produced.

Nearly all movements are complex and most of them involve the action of levers. There are three parts to a lever. There are three kinds of levers used in mechanics according as fulcrum, load or power is centrally placed between the two. In the skull articulation with the vertebral column the fulcrum is central; when we stand on tiptoe the load is central; When we hold a book in the hand the power (muscle) is central.

Vertebrate animals have the skeleton internal, invertebrates have it external, as in the lobster. All three parts of the skeleton, (bone cartilage and ligament), are constructed of connective tissue cells and fibres. In vertebrates the bone has a special arrangement of connective tissue fibres and lime salts are precipitated around the fibres, especially tricalcium phosphate. The bone cells are fibroblasts and blood forming cells. *The bones are the manufacturers of blood cells for the whole body. They produce one million million new red blood cell a day. They also manufacture white blood cells.* Scavenger and fat cells are also present in bone. The white cells constitute 30% of the weight of bone and give it strength--double that of oak.

Bones are elastic when fresh but the elastic fibres are short lived and bones of old people are brittle and easily broken.

For the composition of bone see your physiology. Tricalcium phosphate makes the bone hard and rigid. A cubic inch of bone will stand a crushing force of more than two tons. This chemical is almost insoluble in water and blood fluids. It is carried in the blood vessels in the soluble salt calcium hydrogen phosphate and in the bones changes to a tricalium salt. *But it may be changed slowly back again into the soluble forms and this is the essence of life, change, growth and disease of bone.*

In the child before its second year the bone salts are constantly changing back and forth. The equilibruim in babies is easily disturbed. Sunlight (ultraviolet rays), liver, cod liver oil (vitamin D.) makes insoluble calcium phosphate and hence more rigid bones. Lack of these influences results in rickets and other diseases. Soluble lime salts are necessary in the body. They assist muscles to work, the heart to beat and nerves to carry impulses.

The *bone has three great functions;* 1. to support and protect the body; 2, make new blood cells; and 3, it is the reserve of tricalcium phosphate.

The number of separate bones in a 40 year old man is 206. In a boy of 14 years there are 250 separate bone masses; in a baby boy there are 270 masses. There are at various times more than 800 parts of bones which ultimately fuse. *New bones appear in a body up to 22 years of age.* At every age up to 22 the number of bones differs in girls. Girls are far ahead of boys in bone formation.

Bones are long, short, flat and irregular. They show on their surfeces processes, ridges, spines tubercles, pits, grooves, notches, and canals. Long bones articulate with other bones at their ends (enlarged). These large ends make joint surfaces larger and offer more surface for attachment of tendons and ligaments. The shaft of long bones is hollow and usually cylindrical. The shape of short bones is determined by their mechanical requirements and articulations. Flat bones form coverings for deeper structures, e.g. the skull covering the brain. Irregular bones of the face support the brain case and fill in irregular spaces between mouth, nose, eyes and ears. Many of these are hollow and contain air spaces connected with the nose. All surfaces of bones are either covered with periosteum or joint cartilage. The periosteum is a tough fibrous connective tissue with some elastic fibres. It has many blood vessels and nerves and to it tendons and ligaments are attached.

Holes at the ends of long bone and on the free surfaces of short bones are for exit of veins to carry away the new blood cells formed in their interior. Minute arteries in great numbers enter bone from the periosteum.

The internal structure of bone is revealed by cross sections of the bone. There are compact and spongy bones. The exterior is compact the interior spongy. In the spongy bone are cavites full of marrow, here the blood cells are formed. The centre of the shaft is a great morrow cavity. The plates, spicules and rods of bone are laid down in development and are mechanically adapted to withstand strain (See histology for study of finer structure of bone and a *full understanding of the Haversian systems*).

The growth of bone is interesting. Bone is rigid and hard yet it *grows rapidly up to the 18th year*. It *may* endure in the ground for 500,000 years. Bones are in constant use while growing and must be hard and rigid enough to support the growing child. After growth has ceased, even in old age, in case of fracture there is sufficient growth to repair it. We know blood constantly dissolves bone and repairs it; and phosphates and vitamin D. make it strong and solid. In old age the destructive activities are greater than the constructive activities and the bones become brittle and porous, are easily injured and do not mend well.

In the first seven weeks of life the human embryo has cartilage only, shaped as a model of the future bone. This is true of all bones except some flat skull bones which are formed in connective tissue membrane. At the end of the second month the embryo is 500 times as big as at the beginning of that month. The body is then one inch long. The femur is 1/8 inch long (in the adult 18 1/2 inches). The femur grows 148 times its size between the ages of 50 days and 18 years. Below, in general, the femur is discussed.

It grows by using the old tissue and replacing it by new tissue. The first bone tissue appears in the femur at age of 50 days. Before this it was all cartilage, about the 45 day the tissue in the middle of the cartilage begins to soak up lime salts and the cartilage becomes rigid and ceases in growth The cartilage cells enlarge their containing cavities by dissolving their walls. Adjacent *cavities* are connected lengthwise and the cells divide a few times. The connective tissue surrounding the cartilage changes. Its cells increase in number and lays down on the cartilage surface a membranous band.

This band is the first stage of bone. For a time it is clear and transparent; then connective tissue fibres appear and it becomes a fibrous membrane with many connective tissue cells on its outer surface. Lime salts infiltrate it, all around the cells. This makes true bone. Meanwhile another layer forms outside the first with the same changes. *Thus a cuff of bone of alternate layers of fibres and cells infiltrated with tricalcium phosphate is formed around the centre of cartilage.*

The cuff extends towards both ends and gets thicker by additional layers on its outer surface. Blood vessels run between the layers. The cartilage cells die and become liquid.

Blood vessels enter the cavities thus formed from the vessels of the cuff of bone. Near these vessels the cartilage dissolves in all directions leaving large irregular cavities. Young connective tissue with active cells comes in with the blood vessels. It proceeds to lay down on the inner surfaces or sides of the irregular cavities layers of bone. The ends of these cavities are not walled in by bone, just the sides are so covered. The blood vessels extend through the ends towards both ends of the bone.

There are thusly three processes going on; *a*, the cuff of bone; *b*, the cartilage becoming calcified as it dies; and, *c*, the invading connective tissue into the cartilage cavities and changing into bone. All three advance with equal speed. The centre at which all three processes begin is called a "*centre of assification*".

As these processes proceed the cartilage grows fast at the ends. It grows faster than bone in thickness as well as in length. All long bones are larger at their ends and have a sort of dumb bell shape. The big ends are of cartilage until a week or two before the baby is born. Soon they must change after birth, or, the growing baby could not sit, stand or walk. Cartilage cannot support weight firmly. The bones must not bend therefore the rapid change from cartilage to bene, except for a thin layer on the joint surface.

If both ends and the middle of a bone are bony substances how can the bone grow in length? It grows in thickness by the deposit of successive layers under the surface of the periosteum. There is no periosteum on the the ends of long bones. These are the ends in the joint and are covered with a surface layer of cartilage from which the bones do not grow. *The growth of a bone in length is carried on, by the interposition of 2 discs of cartilage one at each end, throughout the period of growth i.e. up to 20 years.*

About 2 weeks before birth there appears in the cartilage of the lower end a centre of ossification. It developes like the first one but more slowly. The 3 processes of bone formation extend in both directions, downwards to the joint end and upwards towards the other centre of ossification. The lower end is not far away, but the bone formation never extends quite to the end. A thin layer of cartilage persists in the joint until worn away in extreme old age.

The upward trend of this centre and the downward trend of the centre at the middle of the bone proceed and should *they meet there would be complete ossification and growth* would cease at their union. But there persists a disc of cartilage at the so called *epiphyseal line*. This disc grows at its centre but on each face it is dying and being destroyed. Speedy centre growth insures its life and it keeps this up for 20 years or somewhat longer.

About six months after birth a third centre of ossification appears at the upper end of the femur. Its upper end becomes bony except for the joint surface and for the epiphyseal line.

The discs of cartilage at the epipyseal line are thus important and precious. Because of them surgeons are especially anxious about injuries near them in persons under 20 years of age *because injury impedes growth of the bone in length*. The amount of growth that occurs after birth, in the femur, is 15 inches and of this 13 inches takes place at the epiphyseal regions. The activity in growth decreases greatly between 15 and 20 years. At 17 years the upper disk becomes ossified and joins with the shaft, and at 20 years the lower end unites with the centre. *There is more growth at the knee end than at the hip end of the femur*. In all bones ossification commences earlier and persists later at the more active end.

The growth of the bone in thickness goes on by deposition of circumferential layers around the outside until the bone attains its full diameter. This process, unless modified, would result in a heavy compact solid rod except for a small canal along the axis. Now solid rods are not as strong as thinner walled tubes of the same weight and length. The shafts of long bones become tubes by destruction of the internal surface of the bone. Growing on the outside and in length the bone at same time is being excavated on the inside.

This is effected partly by the loops of blood vessels in the interior. Lime salts are dissolved in proximity to small blood vessels with active circulation. Other active excavating agencies are groups of connective cells. From 2 to 40 or more *fibroblasts* merge into masses. These cells called *osteoclasts* destroy the bone. There appear to drill long tubular holes lengthwise through the inner surface of the bone. Young connective tissue cells and blood vessels enter these tubes and put layers of bone on the walls, these may be 20 to 30 of these layers. Thus the *haversian systems are made running lengthwise*. Later on more osteoclasts destroy these systems, except the outermost enveloping layers escape the destruction. Osteoclasts are active through life. In old age they predominate and bones become porous and weak and easily fractured.

Throughout life irregular cavities exist in the bones. In these caverus and their connecting galleries the young connective tissue has another task besides the above mentioned duties. They become bone marrow and form every day one million-million red blood cells and many thousands of white blood cells.

THE PELVIS 骨盆

Differences 分別 in the Male and Female Pelvis. The pelvis is formed by the right and left os coxae 髖骨, the os sacrum 坐骨, and the os coccygeus 尾骨. In the pelvis are two subdivisions: (1) An upper part which lies above the plane of the ileo-pectineal line 髂恥骨線. (2) A lower part which lies below this plane.

The upper part, formed by the ossa iliaca 髂骨 and part of the basis ossis sacri 骶骨底, is known as the pelvis major 大骨盆, or false pelvis. It bounds the lower part of the abdominal cavity and affords support to the abdominal viscera 臟腑.

The lower subdivision 再分 is the pelvis minor or true pelvis. In it are situated the:—

a. Lower end of the alimentary canal 育道

b. Urinary bladder 膀胱,

c. Internal genital organs in female,

d. Part of genital apparatus in male.

Apertura pelvis superior (pelvis inlet) is upper opening of pelvis.

Apertura pelvis inferior (pelvis outlet) is lower opening of minor.

The plane of the pelvic inlet is very oblique and is inclined to the horizon 50-60 degrees in such a way that the opening leads downwards and backwards from the pelvis major to the pelvis minor. The brim of the pelvis or boundary of the apertura superior is known as linea terminalis 界線 and consists on each side of a pars sacralis 界線骶部 pars iliac 界線髂部 and pars pubica 界線恥骨部 The pars sacralis passes outwards on each side from the promontorium to the anterior edge of the sacroiliac articulation, and forms the seperation between the basis ossis sacri and the facies pelvicae of the os sacrum. The pars iliaca is formed by the linea arcuata and separates the fossa iliaca from the pelvic aspect of the ilium. The pars pubica is mainly formed by the pect, ossis pubis and the posterior part of the upper edge of the public bone close to the symphysis 聯合. The circumference 周圍 of the superior angle is greater in the female than in the male and in the male the aperature is encroached upon by the promontorium of the sacrum to a much greater degree than in the female.

The form, size, and inclination 傾斜 of the pelvic brim of the female skeleton is important.

The diameters of the opening are transverse, oblique, antero-posterior. The transverse is the longer, average length is 5 1/4 inches. Antero-posterior, the shortest, also called conjugate 連合 is 4 1/2 inches. Oblique has average length of 5 in. The outline is oval. In the male all these diameters especially the transverse are smaller than in the female, and the outlet of the opening is somewhat pointed anteriorly and "heart-shaped" owing to the forward projection of the promontorium.

Apertura inferior in outline is very irregular. In the dry skeleton 5 bony projections around the opening:—

a. Tip of coccyx 尾骨尖 posteriorly.

b. Spina ischiatica 坐骨棘, two on each side.

c. Tuber ischiatica 坐骨結節, two on each side.

Separating these are the incisura ischiatica major and minor 坐骨大小切迹 on each side and the angulus pubis 恥骨角 or subpubic angle in the middle line infront. On each side of the os coccygis a part of the boundary of the apertura inferior is formed in the dry skeleton by the lateral edge of the lateral part of the os sacrum. In the living subject the boundary of the lower part of the pelvis is to a large extent formed by the ligamentum sacro-tuberosum 骶結節靭帶 and sacro-spinosum 骶棘靱帶, or greater and lesser sacro-sciatic ligaments, which pass from the side of the os sacrum and os coccygis to the tuber ischiaticum and the spina ischiaticum. These ligaments bridge across and convert the incisura into formina known as the foramina ischiaticum major and minor 坐骨大小孔.

COMPARISON OF MALE AND FEMALE PELVES.

男女骨盆之比較

1. In female the inferior aperature is larger.
   女盆下口較大
2. Tuber ischia lies further from medial plane in female.
   女坐骨結節離盆中平面較遠
3. Spinis of ischium points less inward in the female.
   女坐骨棘較男者少向內
4. Tip of coccyx tilted less forward in the female.
   女尾骨尖少向前
5. Angle of pubic bones greater in female, and less in male.
   女恥骨角較大(男較小)
6. Incisura ischiatica wider and shallower in female.
   女坐骨切迹闊而淺
7. Cavity shorter and more roomy in female.
   女盆腔較短而大 寬)
8. Os sacrum wider and shorter in female.
   女骶寬而短
9. Female pelvis as a whole weighs less.
   女盆之重量較男者輕
10. Surface of the bone is smoother in the female.
    女盆骨面較滑

11. Spina iliaca are anterior and superior in female.
女髂骨棘向前上

12. Crista iliaca is further from mesial plane in female.
女髂緣離中平面遠些

13. The tubercle of pubis is further from mesial plane in female.
女恥骨結節離平面中軸較遠

14. The length of symphysis is shorter in the female.
女恥骨縫較男短

15. The facies auricular is smoother in the female.
女髂之耳面較滑

16. Sulcus for anterior sacro-iliac ligament is deeper in the male.
男骶髂前韌帶之溝較深

(Notes from Ellis "Man and woman").

The pelvis constitutes the most undeniable conspicuous 顯著, and unchangeable 不改變 of all the the bony secondary sexual characters. In lower races differences between male and female not well-marked viewed from behind.

The pelvis has developed in the course of human evolution. In some dark races it is ape-like in narrowness. It is the proof of high evolution and the promise of capable maternity.

In men and women of the same height the girth 周圍 of pelvis is as much as 6 inches larger in woman.

The girth of thigh is most constant and absolute external measurement, constantly greater in woman. Its size largely depends on size of pelvis.

The pelvis of animals forms an arch which supports the posterior half of the body. It is at right angles to the weight bearing axis and arch is free for exit of offspring. In man the pelvis supports the weight of the whole trunk, and the weight falls in almost the same line as axis of exit from the body.

The adaptation of the pelvis to the erect position becomes a very delicate adjustment 整齊 of physical forces, and as this adjustment must be greater in women, it is in women more highly developed than in man who retains more animal-like characters.

Sexual differences in the pelvis become marked as soon as the bones begin to ossify—i.e. in 4th month. During foetal 胎 life the essential sexual characters are as well defined as in the adult, and differences which occur during growth between adult and foetal forms, due it may be to the influence of pressure or muscular action, affect both sexes alike and do not account for characteristic features of the female pelvis.

Comparison of the breadth of the pelvis with its length, we find that with vertebrate evolution from lower animals to Europeans the pelvis has constantly become broader in relation to length, and in woman more than in man. As we rise in series the pelvis enlarges, becomes ample.

Breadth of sacrum in woman shows higher evolution. In apes 無尾猴 and lower humans it is long straight and narrow. The sacral index or degree of breadth show a progressive rise from Hottentot to European.

External indication of size of pelvis, a lozenge-shaped 菱餅狀 space on surface of sacrum—laterally two dimples corresponding to post. sup. spines of ilium, above the spinous process of last lumbar, and below where gluteal fissure 臀筋汋裂 begins. Some consider these secondary sexual characters.

Relation of pelvis to spinal column results from forces which influence or modify the adoption of the completely erect position. Verticality 垂直 is in direct ratio with evolution and nutrition, while horizontality 水平 is in inverse ratio. The apes are but imperfect bipeds 兩脚 with tendencies towards the quadripedal 四脚 attitude. The human infant is as imperfect a biped as an ape. Savage races do not stand as erect as civilized races. Country people tend to lean for ward. Women are more curved forward than men.

In verticality the relations of femur, tibia, and astragalus 距骨 are compensated in the degree of curvature in spine.

The carriage of the female has a sinuous character and a forward tendril-like motion in contrast to rigid convex (almost) carriage of man. The head of female tends to fall forward. From childhood the skull is slowly tilted 傾 more and more backwards, thus more and more weight behind. The female skull is less tilted back than the male, thus more childlike. The head is more tilted forward in female and the pelvis tilted farther back. This is due to a partial arrest of an infantile 幼穉的 characteristic.

The angle formed by the superior plane of pelvis with the horizon when standing is 70°--80° in infants, 50°--55° in men, 55--60° in women. This inclination better supports the pelvic contents, When the angle is small there is a tendancy to uterine prolapse. Racial differences exist in women. In Mexic in women the angle is 60--65°

In harmony with this the anus appears farther back and nearer the coccyx in women than in men. In apes and in some children there is a long distance between anus and coccyx. In some African races the vagina is so directed back that they practice quadrupedal coitus. Older anthropologists judged inclination of pelvis with direction of urinary stream, e.g. forwards — humanlike, backwards — animal-like.

The inclination of the pelvis is related to the saddleback, or lumbo-sacral curve, which in its exaggerated pathological 病體學 form is called lordosis 脊梁前曲. This curve is only slightly marked in the ape and does not exist in the human embryo. It is one of the superior qualities of the African races and appears to be increased by muscular action of the back, as in rowing upright, and in carrying children on hips. It is more pronounced in women than in men, and is well marked in Spanish 西班牙 and Creole 西班牙之土人.

Lumbo-vertebral index show tendency to curvature. chimpanzee 117°, native Australian, 108°, negro 105, European 96°. (The lower the number the higher the curve). The curvature 彎曲 increases on the whole as we ascend the scale of races of man, and tends to be greater in women. The degree of curve is in proportion to inclination 傾斜 of sacrum and prominence of the buttocks in relation with this sacral obliquity and is an index of functional utility. Sacral obliquity may be due either to (1) acute sacro-vertebtal angle, or (2) to a pronounced lumbar curve.

Comparison of greater curvature in men and women:

(1) Relatively greater length of lumbar region in women.

(2) Curve begins higher and attains its summit at a higher point in women (this with greater relative size of abdoman fits her for maternity).

(3) In women the lumbar region is 32.8% of whole column, in men 31.7%, while dorsal section is 16,5% in men and 56.8% in women. Thus the lumbar region in women is longer and is moulded on a different plane, it is more arched and vertebrae are moulded to suit the arch. This may be accounted for by different habits of the sexes. No other part of spine is more readily moulded by functions because it is there we have the greatest degree of superincumbent pressure.

Rosenburg concludes spinal column is shortening in man. The ancestral 祖先的 from had 25 moveable vertebrae anterior to sacrum. Now there are 24 and there will be 23. On the transverse process of 1st, lumbar of foetus is a cartilaginous rudiment of a rib which fuses with transverse process. This suggests ancestral type found in gibbon, 13 ribs and 25 moveable vertebrae. This type is sometimes found in man today. The column with most reduced number of vertebrae always occurs in women.

The lumbosacral region of spine because of its position of very unstable equilibrium may exhibit both retrospective and prospective variations.

Woman's body seems to be more reminiscent of quadrupedal posture than man's and there are reasons. In both sexes pathological 病證 and unwholesome 不宜健康 conditions have been encouraged or produced by erect position, e.g. hernia, stone, appendicitis, 瀾尾炎 varicose veins, exposure of great arteries to injury, torpidity of gall bladder, 膽囊 greater constriction 收縮 of lungs hence less power of long muscular exertion, liver disorders on account of trouble of lifting blood thro' vena cava, and tendency to syncope 暈倒. Woman shares these disabilities with men but also the erect position seriously affect sexual organs and very definitely interfere with maternal functions. In the male the erect position only slightly affects sexual organs, e.g. scrotal varicosity 膨大, and exposure to injury.

In the quadruped parturition 生產 is comparatively easy the pelvis offers no serious obstacle.

The shape of female pelvis is a result of compromise between forces: *a.* support.

b. ease in delivery.

We must remember that along with erect position the head of child also increases, thus still another obstacle to delivery and to adaptation which might have otherwise taken place. The struggle has been fierce, and no wonder death in childhood has increased in the higher races, and woman seems to have suffered more than man in the upward struggle.

In no other animal is there such a distinction between the pelvis of the male and female. Uterine displacements

子宮轉移位置 are almost unknown in quadruped. The "knee-elbow" position helps to restore to normal position, and is decidedly quadruped in character.

The erect position placed nature in an awkward dilemma **進退兩難** It is necessary for the stability of the body and for the support of organs that the bony girdle be strong, hard, and inner channel small. But for the higher evolution of the race the bony girdle must be less stable by the increased size of outlet to permit birth of larger headed children.

The most delicate adjustment **相合極佳** is required to prevent these directly opposing necessities from conflicting with each other. While the adjustment is not absolutely perfect, and we suffer from disadvantages of biped position. The higher development of race has caused, and will cause, an increased expansion and development of pelvis.

Table indicating level of the more important structures in relation to spines of Vertebrae:— (C1142).

棘突.

Spines of Vert.		*Origin of Spinal Nerves.*		*Level of other Structures.*
1	Cervical	2	Cervical	Soft palate.
2	"	3 & 4	"	Isthmus of fauces **咽峽**.
3	"	5	"	Upper part of epiglottis **會厭軟骨**.
4	"	6	"	Vocal folds.
5	"	7	"	Conus elasticus **喉彈力圓錐**.
6	"	8	"	Arch of thoracic duct **胸管** and commencement of trachea & aesop.
7	"	1 & 2	Thoracic.	Inferior end of cervical enlargement of spinal medulla. Inferior cervical gang of symphatheties.
				Apices of lungs.

1	Thoracic	3	Thoracic.	Summit of arch of subclavian.
2	"	4	"	Median angle of scapula. Just above level of highest part of arch of aorta.
3	"	5 & 6	"	Root of spine of scapula. Arch of vena azygos 奇靜脈. Highest part of inf. lobe of lung. Termination of arch of aorta. Bifurcation 歧叉者 of trachea. Lower limit of sup. mediastinum 上縱隔障. Angulus sterni.
4	"	7	"	Commencement desc. thoracic aorta. Bronchi. Superior limit of heart.
5	"	8	"	Centre of root of lung. Mitral orifice.
6	"	9	"	Tricuspid orifice 三扇.
7	"	10	"	Inferior angle of scapula. Orifice of inferior vena cava. Right arch of the diaphragm.
8	"	11	"	Lowest limit of the heart. Left arch of diaphragm. Fundus of stomach. Xiphi-sternal articulation 胸骨劍突.
9	Thoracic	12 Thoracic 1 lumbar	}	Superior limit of spleen 脾.
10	"	2 lumbar		Cardiac orifice 口 of stomach 胃. Upper end of lumbar enlargement. Lower border of lung posteriorly.

		Apex of spleen. Superior end of left kidney 腎. Lesser curvature 胃小彎 of stomach.
11 "	3 & 4 "	Lower limit of pleura 胸膜 at vert. column. Suprarenal gland 腎上腺. Superior end of R. Kidney. Body of pancreas 胰腺. Lesser curvature of stomach.
12 "	1, 2, 3 Sacral	Conus medullaris 脊髓圓錐. Lower limit of pleura (mid-axilla.) Hila of kidney. Head of pancreas. R. flexure 曲 of colon. Portal vein. Descending part of duodenum. Greater curvature of stomach 胃大彎. Bile duct.
1 Lumbar	4 & 5 Sacral	Level at which pleura crosses 12 rib. Inferior end of spleen. L. flexure of colon. Superior part of head of pancreas. Pylorus 幽門.
2 "	"	Commencement of uterus 子宮. Lower part of head of pancreas.
3 "		Inferior limit of spinal medulla 脊髓 of child. Inferior ends of kidneys.

	Horizontal 水平 part of duodenum 十二指腸.
4 "	Highest part of crest of ilium.
	Bifurcation of aorta 主動脈叉.
	Umbilicus 臍.
5 "	Common iliac arteries.
	Valve of the colon.
1 Sacral	Sacral promontory 腰骶角.
2 "	Lower end subdural space 腦筋衣下間,
3 "	Superior end of gluteal cleft.
	Inferior limit of sub-arachnoid 腦潤衣下間 and sub-dural spaces.

CARTILAGE 軟骨

(*See Joints p.*)

Cartilage is firm tissue, very elastic and can be freely cut in all directions, it bends readily and returns to its original shape when pressure is removed. Usually it is of blue-white or yellow colour. It is opalescent in thin slices but is opaque when thick.

Cartilage is surrounded on its outside or external surface with fibrous tissue which contains blood vessels, there is no fibrous tissue on the surface of the joint cartilage.

Cartilage is found connecting the ribs with the sternum, the joint surfaces are all covered with it; and there are discs of cartilage between the vertebrae. Bone and cartilage are closely connected with each other, they and ligaments are composed of connective tissue.

Connective tissue may may be soft tissue like wet cotton, or hard as in cartilage, bone, ligaments, tendons or fascia. It contains white or elastic fibres, the amount of which depends on the strength or elasticity that is required in its use.

Whenever elasticity, flexibility, moderate firmness compressibility, total lack of sensibility or rapid growth with no blood vessels, is required, there one finds cartilage, e. g. in the thorax where the ribs join the sternum, every movement of respiration and in every twist or movement, the body needs cartilage. Because of this yielding quality due to cartilage the throrax may be compressed a great deal. Through cartilage the body yields somewhat to blows and compression and fractures are prevented.

Cartilage in found at the ends of long bones and acts as buffers or shock absorbers. It is found in the discs of the vertebral column where much twisting occurs.

Cartilage supports the nose and ears. It is also found in the trachea, bronchial tubes and larynx.

In the lowest verterbrates e. g. sharks and sturgeons it is the only supporting structure in their body. Wherever rapid growth is required there cartilage is found e. g. in the foetus. 胎兒

Where connecting tissue is compressed it tends to become cartilage. The change in the cells from one to the other is not great, the white fibres become more elastic and some altertion in the tissue fluid occurs. In this change the cells develope fat particles and glycogen; the intercellulor fluid first becomes mucus which hardens into a semi-transparent material peculiar to cartilage. This mucus is combined of several chemicals (an albumen (like white of egg) and another albumen which sets into a glue-like jelly or material, like horn, and an organic acid). As the cartilage sets the organic acid combines with sulphuric acid then the whole mass sets into gristle and finally becomes cartilage. The cartilage cells are embedded in this matrix and it is incorporated into all fibres white and elastic.

There are three kinds of Cartilage *hyaline*, 透明 *fibrocartilage* 纖維軟骨 and *elastic*. *Hyaline*, (glass), has many white fibres which seem homogenous, but by treatment with chemicals the fibres are seen. This kind is common on the ribs and in freely moving joints. *Fibro-cartilage*. Here we find many white fibres which are coarse and visible. It is opaque and is found in the discs of the vertebral column. *Elastic*, here most of the fibres are elastic and hence of a yellow tint. It is not transparent and is very flexible. It is found in the ear and epiglottis.

Nutrition and growth of cartilage. In all its forms, the cells are imprisoned and are isolated but alive and growing. They are nourished by fluids which soak through the cartilage. *Cartilage has no blood vessels nor lymph vessels.* Cartilage takes up fluids as leather soaks up oil. Pressure (intermittent) assists in diffusion of the fluid. In joints the cartilage with no blood vessels to be injured, and with intermittent pressure applied (as in walking) favours the flow of the fluids.

The encased cells grow and multiply, the whole mass grows including the cells. Young cartilage grows with great speed. Growth is necessary to early life. It grows partly by adding new cartilage to its surface. Cartilages are covered by a fibrous envelope, this is vascular and from it nourishment is given to the cartilage. This covering forms new cartilage which is constantly being deposited on the surface of the old cartilage. This envelope covers all cartilage except on joint surfaces and where cartilage joins the bone.

Cartilage also grows by interstitial growth i.e., in the interior of its mass. New molecules are being added amongst the old ones, all the old and new are being adjusted so that the general shape of the mass remains the same while it is increasing in size in all directions. The cartilage during this growth seems to become almost as a fluid. The cavities, in which are the cells, grow larger, a cell divides into two cells and are separated by a wall of the general substance and each then is in its own cavity. Sometimes small groups of cells remain in one cavity. When the cartilage gets old it tends to take up calcium salts and some cells get precipitated in it. Thus its flexibility 屈能 and elasticity 弾力 are lost and it becomes rigid. These salts appear in the larynx at about 20 yrs of age and in other parts at varying times. They never come in elastic cartilage.

Cartilage has no nerves, so one does not feel pain when it is injured. This is fortunate as in jumping one's whole weight comes with force on the joint cartilages but the cartilages absorb shock and do not feel pain. The surface of cartilage has much wear and tear and it must grow to constantly replace lost substance. This is done until in old age (80 years) sometimes the cartilage fails to grow, and it wears away, bare bone meets bare bone, and the joints grind, creak, burn and are full of pain.

Bone grows from young connective tissue, i.e. from the same origin as cartilage. Intermittent pressure tends to form cartilage, while an abundance of calcium salts and connective tissue tend to form bone in regions in which the circulation of the blood is sluggish. In the embryo, cartilage is formed in all the places in which cartilage is found and in the adult, and also in nearly all places where bone is found in adult. Nearly all bones are first modelled in cartilage. Only a few, e.g., the flat skull bones, are formeddirectly from connective tissue.

THE SESAMOID BONES 子骨

These curious little bones attract curiosity and are mostly lost sight of in the study of anatomy. Their exact number, precise association and function are not well known.

The digital sesamoids are interesting and at least one, that to the great toe, is of practical surgical importance. The patella 髕骨 is a sesamoid bone. It is the largest of its kind, is specialised and is not typical. The digital sesamoid bones when fully developed in animals are small, shaped like dumb-bells; are adherent to the palmar part of the capsule of the metacarpo-phalangeal and interphalangeal joints; lie transversely to the axis of the digits and across the dumb-bell runs a grove which acts as a pulley surface for the flexor tendons.

In man where the developement of these bones is not fully attained, there is no connection between the two ends of the dumb-bell, and there are two separate bones in the most complete forms. Sometimes only one bone is found. These bones are developed in cartilage soon after the third foetal 胎 month and remain cartilagenous during childhood with the ossification beginning about the fifth year.

Their number varies, as many as twelve may be found in the hand and foot. Xray examinations show them to be frequent. Nearly always the bone or bones exist in the adult at the flexor surface of the metacarpo-phalangeal joint of the thumb. Frequently double, these ossicles are adherent to the volar ligament. Often the radial sided bone is the larger. Somewhat less frequently there are found sesamoid bones at the proximal interphalangeal joint of the thumb. A sesamoid bone on the ulnar side of the metacarpo-phalangeal joint of the little finger is very common. Also there occurs about as frequently a sesamoid to the radial side of the metacarpal-phalangeal joint of the index finger. Sesamoids are rare in any other sites in the hand. In the feet a pair of sesamoids at the metatarsic-phalangeal joint of the great toe are constantly found. These are larger than those found in the hand and are as a rule quite small. Sesamoids have been explained as due to pressure, age, and hard labour. Probably they are not due to any of these reasons.

In animals the sesamoids are always present in association with the short intrinsic digital flexors, they are probable tell-tales of the former presence of short digital flexors lost through evolutionary changes.

CIRCULATION OR BLOOD

(See head and brain pp.)

The blood and blood vessels are essential common carriers for the human body. The total length of this system is approximately 100,000 miles in an adult man. The muscles have 60,000 miles of this total. The blood serves 27 million million cells. The blood carries food and oxygen 養氣 within the reach of every cell, and carries from each cell carbon dioxide and its special products and waste. It also carries the hormones. 內泌素

This transportation system is unique.

1st. It is submerged in and carries salt water. 85% of the weight of the human body is salt water and all cells live in it. 2nd. It is a continuous network of tubes. 3rd. All the system is a continuous ever-moving-circulating fluid, the blood. The blood holds in solution all food and this escapes through the tubes walls by little holes which close automatically. 4th. All the work is done in the dark.

The blood in an average adult has a volumn of 15 pints. It is constantly in circulation. It is made up of blood fluid and blood cells. The fluid is called the plasma 漿 and carries food, hormones and cell products in solution. It is constantly receiving and giving up these substances but the exchange is so steady and a regulating mechanism (kidneys) so efficient the plasma nearly always remains of the same constitution. The blood carries heat from the muscles.

The component parts which comprise the blood transportation system are the heart, the arteries, the veins, and capillaries. In the living body every bit of space in this system is full of blood and contains all the blood there is in the body.

The continuous stream of circulating blood goes in an unbroken circle or course. It passes in succession from the right atrium through the right ventricle 心室 of the heart to the pulmonary artery and lung capillaries, thence to pulmonary veins, left atrium and left ventricle of the heart, to the arteries (except pulmonary), all capillaries (except pulmonary), all veins (except pulmonary), and back again to the right atrium 心房 of the heart.

Valves in the heart and veins permit flow only in above direction. There are therefore, as it were, two sets of blood vessels—one for the lungs and another for the rest of the body. We speak of the pulmonary and the general circulation. This is an apparent or arbitrary differentiation for reasons of convenience in explaining function or physiology.

For the same reason one speaks of the system of the liver or portal system. In all these systems the blood must go through capillaries in order to pass from arteries to the veins. *Blood Cells* are of 2 kinds *red* and *white* with very different functions *Red Cells* number 23½ million million. They are special carriers of oxygen and carbon dioxide—their shape is circular and they are biconcave. The diameter of these cells is 7/25,000 inch and their thickness is ¼ of their diameter. They give a red colour although they are not themselves individually red but orange yellow.

They have no nuclei and are imperfect cells soon to die. Three weeks is their maximum of life i.e. one million million cells die in 24 hours and have to be replaced and disposed of.

In the embryo 胚胎 they are formed in the liver, spleen and bone marrow. Prof. Maximow showed that in the interior of the bones the capillary tubes expand into irregular sacs in the spaces of the spongy tissue. The red cells are formed in great numbers in these spaces just outside the blood soc. As they grow they exert pressure in one spot and break through the walls into the blood stream, many thousand millions each day. The walls are alive and assist in this passage. This opening rapidly closes. The spleen and liver are the graveyards of the red cells. They are broken up chemically and stored temporarily and used again for other purposes. We eat ourselves.

White Cells 白血球 These are less mumerous than red cells 1-666. They are of 5 varieties and all have nuclei. Many are larger than red cells and are capable of slow independant movement. They are strongly attracted by bacteria which they eat and digest. These cells will crawl out of the body. When outside the blood vessels they are called wandering cells. In bacterial diseases their number is doubled or tripled hence in blood counts the number is important for diagnosis. When the bacteria over-come the white cells the white cells are killed and we have *pus*.

In blows or wounds which do not break the skin both white and red cells get out. The red ones make the colour which follows a bruise and the white cells and connective tissue cells clean up the area.

The white cells do not live many weeks. They are eaten up by other white cells etc. especially in the wide capillaries of the liver, spleen and bone marrow. 骨髓

Platelets 血小板 In the blood are many millions of these tiny bodies. They are smaller than red cells. When the blood comes in contact with the air or foreign substances these platlets with the help of white blood cells and the blood plasma form fine waxy filaments. 絲 These become entangled into a *clot* which adheres to the edges of wound and everything in the vicinity. This closes the wound unless it be too large and the blood vessel cut be too big.

THE HEART

The heart is the motor which drives the blood in a ceaseless stream throughout the continuous circulatory system. Its cavities expand and suddenly contract. When it expands it receives blood from six veins and when it contracts it drives blood into two arteries. Valves permit flow in one direction only.

Each contraction of the heart forces out five ounces of blood, 2½ into the pulmonary and 2½ into the aorta arteries. It does this seventy times a minute during normal life. It forces, therefore, under ordinary conditions 4,000 gallons 加倫 a day throughout the body. It has force enough to overcome air and muscle pressure, gravity and friction of the walls in more than 100,000 miles of capillaries, arteries and veins. In the large arteries its speed is about 55 feet per minute.

Its work is enormous—a person lying in bed for a day, the heart's work corresponds to carrying a weight of 150 lbs up a hill 500 feet in height. In an athletic contest it may work 3½ times its usual capacity. In a day of moderate activity its work corresponds to lifting a man 1000 feet. The heart lies in the thorax. The sternum 胸骨 is in front and the vertebrae behind it. On each side of it are the lungs, these are elastic air cushions allowing the heart to expand

and contract. The apex of the heart is directed downward and to the left, its base upward and to the right.

The average heart is five inches long, 3½ inches wide and 2½ inches thick. It weighs 11 ounces. It is enclosed in a tough fibrous sac, the pericardium, 心外衣 which prevents overdistension. *Between the heart and this bag is a small* amount of lubricating fluid to reduce friction. The heart has four chambers, two, the right and left atrium receive blood; and two, the right and left ventricles discharge the blood.

The left atrium receives blood only from the lungs and opens into the left ventricle. Its opening is guarded by the mitral valve. The left ventricle forces blood into the aorta and to the whole body except the lungs. The right atrium receives all the blood of the whole body except the lungs. It opens into the right ventricle through the tricuspid valve. 三尖瓣 This ventricle forces blood through the lungs only and from them it is returned to the left atrium.

The cavities of the heart do not connect directly. Each has a capacity of 2½ ounces of blood. The lining of each cavity is similar to the capillary walls. It is a continuation of that continuous inner tube of the whole system, it also extends over the valves. Outside the lining is the heart muscle.

The heart muscle does all the work of the heart, it is not equally thick in all parts of the organ. The layer around the left is four times as thick as that around the right ventricle because the former drives blood to the lungs only, the later to the rest of the body. The muscle wall of the strium is thin, in simply drives blood to the ventricle.

Heart muscle is striped it acts quickly but not as quickly as skeletal muscle. Its contraction takes three times as long. It contracts rhythmically of itself but is influenced and regulated by nerves. The heart itself, outside the body, or bits of its muscle, will contract for long periods if kept in a proper solution. This proves that it is not entirely nerve connection with the rest of the body that originates and continues that contraction of heart muscle.

The muscle fibres are branched and they join other fibres into a continuous mass. The fibres of the right ventricle also connect with those of the left ventricle —the fibres of the right atrium are continuous, with those of the left atrium; the fibres of the atrium are not connected with those of the ventricle. But they must cooperate perfectly in each heart beat. This is secured through the wonderful mechanism of the *bundle of His* 希司氏束. Contraction of the heart muscle in each beat commences high up on the atrium near where the superior vena cava 上腔靜脈 enters. It moves from there towards the opening into the ventricle. It forces the blood fill and distend the ventricle. If the wave of contraction went on it would cause the ventricle to contract in the same manner as the atrium i.e. from top to bottom but the valves through which the ventricles force their blood are on the upper part of the ventricle and the blood must be forced from the bottom part of the ventricle to its upper part i.e. to the aorta and pulmonary arteries. Now the force of the contraction of the ventricle is four lbs to the square inch, it therefore must be directed to an opening. *The ventricle must contract all over at the same time, the muscle of His brings this about.* This muscle bundle is a cord of embryonic muscle tissue along which a contraction wave moves quickly. Its upper end is on the lower part of the partition wall between the atria and it passes down into the wall between the two ventricles. It forks and one part goes to each ventricle and spreads widely over the inner surface of the ventricular muscle. At the end of the contraction of the atria when the ventricles are full of blood this band directs the contracion so that the impulse affects all the *ventricular muscle at once* thus the blood current is towards the valves which are at the upper not lower end of the cavity.

The pressure contracting muscle is great and closes the valves to the atria and opens these the aorta and pulmonary arteries. The ventricles thus suddenly discharge their blood into the artery. The contraction of the ventricle lasts 3/10 of a second. When it ceases, pressure in the ventricle ceases; the valves in the arteries close suddenly and the ventricle begins to fill again with blood.

One can hear the valves working—the first sound is made by the closing of the valves between the atria and ventricles and the second sound is caused by the simultaneous closing of the valves of the two great arteries.

The arterial valves are each made of three pockets. These flaps support one another and they can withstand pressure of four pounds to the square inch. The arterial valves are attached at their bases to firm fibrous ring which do not change in size but the valves detween the stria and ventricles must close larger, constantly changing openings which are attached to muscle only. The would seem to be greater danger of being reversed by pressure, but a beautiful mechanism makes them secure.

Strong tendinous cords are attached to each cusp, on the side the pressure comes from. These are inserted into little columns of muscle projecting from the muscle wall into the cavity. When the wall contracts they contract and pull on the cords and give firmness to the valves.

The heart beat is usually faster the smaller the animal, e.g. elephant 27, horse 44, man 70, woman 75, dog 110, rabbit 150, mouse 700. In man the rate is at birth 140, infant 120, child 100, youth 90 and adult 70.

ARTERIES

All parts of the circulatory system that carry blood *from* the heart are called arteries. The large ones leave the heart the pulmonary and the aorta. The first goes to the lungs the later supplies the capillaries of all the body except the lungs. Each of these arterial systems is like a tree with trunk, branches and twigs. Each twig connects with a capillary network and is about 1/2500 inch in diameter.

The *fundamental part of the whole circulatory system* 血循環系統 *is the delicate inner tube.* Outside of it in arteries are coats of elastic, white connective tissue and muscle fibres. The elastic fibres withstand pressure, the white fibres give strength and prevent over distension, and the muscle fibres regulate the size and hence amount of blood to the part served. The blood pressure in the arteries is 3 lbs to the square inch in the aorta, 主動脈弓 this steadily diminishes to about one pound in the terminal twigs and 6-7 ounces in the capilaries. The elastic fibres make the blood flow in a steady stream and not by jerks. The strength of the white fibres in a young person is sufficient to withstand 100 pounds to the square inch before bursting. The muscle fibres are placed in a circular manner about the arteries like a sleeve. By contraction these fibres perform a valuable service in regulating the flow of the blood. At rest the arteries contract and little blood passes. Active muscular exercise may cause 5 times as much blood to flow in inactive muscles. The blood is shunted to the part that is most active, the brain or stomach etc., as case may be. Severe mental effort is best on an empty stomach so that blood can go to the brain. The contraction of the arteries is under the control of the autonomic nervous system and the adjustments are made without consciousness. After death the elasticity of the arteries is sufficient to send the blood into the veins, so the arteries of a dead animal are empty. This may explain the Chinese anatomical knowledge that the blood vessels carry air and blood.

The arteries vary greatly in size as some parts need more blood than others. The amount of blood needed per minute per pound of weight is on the average 4/5 ounce for the leg, skeletal muscles 2 ounces, stomach 3 ounce, intestines 5 ounces, brain 22 ounces, kidney 22 ounces and cortex of suprarenal gland 100 ounces.

During life the arteries have a pulse which corresponds to the beat of the heart and is not the movement of the blood. The wave of the pulse passes about 10 yards per second in the arteries but the blood flows less than 1 foot per second and in the capillaries only about 1 inch in 36 seconds. There is normally no pulse in the capillaries or veins. The arteries are usually deeply placed in the muscles for protection from injury. A wound of a large artery means quick death unless repaired at once.

VEINS: The tubes carrying blood *to* the heart are called veins. The pulmonary veins carry blood only from the lung capillaries to the heart. The rest of the veins of the body except those of the heart itself constitute the general veinous system. There are two main trunks the inferior and superior vena cava both of which separately enter the right atrium but their branches are connected where they lie near each other. Small veins tend of form networks called veinous plexuses: their end twigs drain capillary plexuses.

The fine *inner tube* of the veins is covered, as in arteries, by the same coats of similar fibres but they are thinner and weaker. The veins have little pressure in them, about 1/10 that of arteries in the limbs: in the abdomen in the inferior vena cava the pressure is 1 ounce per square inch and in the thorax the pressure in the superior vena cava is less than nothing during inspiration. 吸入 The same is true of the great veins of the neck. The muscle fibres of veins regulate their size. If all the veins were distended they would hold all the blood in the body. The pressure in the veins is scarcely sufficient to maintain a continuous flow to the heart. That flow is assisted by the inspiration of air into the lungs.

VALVES OF VEINS. The flow of blood is also assisted by the action of valves. 瓣 The medium sized veins 1/12—1/2 inch, usually possess valves. They are shaped like the valves of the aorta but have either two or one valve according to size of the vein. Muscle movement makes pressure on the veins and assists blood flow to the heart; for the valves permit flow only in that direction. In man, his erect position makes return circulation in the legs a great difficulty. This is assisted by muscle movements and by an added number of valves. In old age and in heavy manual labour the valves become incompetent and dilate and there are formed varicose veins. 靜脉曲張 If the muscular movement is too continuous the pressure inside the deep fascia is great and flattens out the deep veins so under these conditions the blood passes to the superficial veins opposite the joints. This is the explanation of the large veins just under the skin of the limbs. The blood only moves 1 foot in 3½ seconds in the veins. A complete round of the blood in the circulatory apparatus is made in about 27 heart beats or 22 seconds.

Lymph vessels 淋巴管 — Accessory Low Pressure Vessels. There are lymph capillaries as well as blood capillaries. These are the vessels which act as carriers of the debris i.e. dirt or bacteria etc. which gain entrance into the connective tissue. They also occure where food, especially fatty food, is absorbed and carried away e.g. in the intestines. Their large inregular capillaries have little or no pressure in them. From them lymph vessels like small white veins lead away towards the root of the neck where they empty into the great veins. They contain many valves which only permit flow the neck.

No other vessels give the lymph vessels any fluid. Their contents are collected from tissue spaces. The cells of their walls are alive and take up fluids from the tissues outside them and give it up to the inside of the capillaries. They actually do this with force which is one factor in lymph flow.

Along the lymph vessels are *lymph glands*, 淋巴腺 Every lymph vessel passes through lymph glands which act as filters. In their interior the lymph seeps through a close sponge-work which contains masses of growing cells. As these white cells mature they wander into the lymph stream and are carried along the lymph vessels to the neck. At the root of the neck these vessels join into a trunk on the right and left sides and empty into a great vein. The entrance is guarded by a valve. The veins have a negative pressure or suction during inspiration and this with muscular movements assists the flow of the lymph.

If bacteria 細菌 get under the skin the scavenger cells of the connective tissue attack them and carry them away dead or alive to a lymph gland. There the bacteria may accumulate. If not too numerous or virulent they are destroyed there. The lymph glands are barriers against entrance of bacteria, cancer cell, etc. into the blood stream.

CAPILLARIES.

In the blood transportation system the capillaries are of exceeding importance. These alone have walls that are permeable 可滲透 and it is through their thin walls that all interchange of the blood takes place between the blood and tissue fluids. Their walls may be likened to tubes of filter paper filled with Salt water submerged in a beaker of distilled water. The two solutions will mingle until both are of the same concentraction and all the water equally salt.

The walls of capillaries behave in this same way. They are made of thin flat cells joined at their borders. They permit solutions of salt and of colloids to go through them, but they are alive and irritable, and they assist things to pass or reject them, that is they choose their work.

The total length of the capillaries is about 100000 miles and their total area equals one acre. Throughout their length and breadth exchange of solutions is *constantly going on*. Piled on each other it would take 30,000 capillary walls to made an inch. From the air sacs in the lung the blood in the capillaries gets oxygen. It goes in solution first through the thin layer of fluid lining the air sac, then through the thin tissue of the wall of the sac, then through the thin cells of the capillary wall and so *into* the blood where the red blood cells take up the oxygen.

From the absorptive cells of the intestines the blood gets food. It goes in solution through the absorbing cells into the space around their bases, through the connective tissue caverns through the thin cells of the capillary walls and so *into* the blood.

The blood gives up exygen and food to *all* the cells of the body. The cells pass from the capillary walls into the connective tissue caverns through the walls of the cells and into their substance. Similarly carbon dioxide, cell products and cell waste pass in solution *from* the cells into the blood.

The capillaries, therefore, are tubes with thin permeable walls in a sea of fluid. Currents of blood flow into the capillaries into the tissues and cells and back again. The body cells help the current to flow and they absorb what they need and throw out the rest.

A man commonly takes in daily 94 ounces of water — he throws out daily 11 ounces in his breath, 22 ounces in sweat, 57 ounces in urine and 4 ounces in his faeces. All this water goes through the capillary walls carrying oxygen, food and waste.

The essential thing is that a stream of blood be kept moving through the capillary tubules, all the other parts of the transportation system, the heart arteries and veins, are all subservient to this essential activity.

To maintain the flow several factors are involved (1) air pressure, 15 lbs to sq. in (2) elasticity of skin (3) muscle pressure (4) the walls of the tubules are alive and tend to contract on the the contained fluides (5) nerve ends reach them influence cantraction (6) contracile cells encircle the tubes and exercise pressure on them. Were it not for the fact that the force driving the blood in the tubes is greater than these factors the capillary walls would be flattened out. That force is supplied by the heart and arteries.

Throughout all the blood transportation system the thin capillary wall is present the whole system is one continuous tube without interuption. The wholle circulatory system is one tube which branches repeatedly and all the finer branches communicate. In the capillaries the fine inner tube is caked and exposed to the tissue fluids.

In all but the finer branches there are coverings for this inner tube. This covering or outer coat of the blood vessels comes from the mesoderm. These outer layers supply the machinery which makes the blood move. This addition in one place is the heart, in other places it constitutes the arteries and veins. The added tissues are muscle, white fibre connective tissue and elastic fibres.

The minute uncovered capillaries are in all parts of the body. The larger vessels connect with the capillary nets. The common centre is the heart. The larger vessels are usually a double system one (arteries) going from the heart, the other (veins) going to the heart.

All its nerves and vessels are at the base of the heart. Two great arteries leave the heart—the aorta and the pulmonary arteries. Two great veins come to it along the right margin, the superior vena cava above and the inferior vena cava below. These bring blood from all the body except the lungs. Four other large veins enter the base of the heart from the lungs. The pulmonary artery goes off from the right ventricle and the aorta from the left ventricle. The superior and inferior venae cavae enter the right atrium. The four or five pulmonary veins enter the left atrium.

APPLIED ANATOMY 應用體學.

The thoracic duct may be blocked by the microfilia nocturna 絲虫蛆 (a parasitic worm) and there arises stasis of chyle and causes its passage in abnormal directions past the obstructions. The abdominal, renal, and pelvic lymphatics become enlarged, varicose 腫大,脹大, and tortuous, and chyle may enter the urine (chyluria), or may enter the tunica vaginalis 陰道粘膜 (chylocele), the abdominal cavity (chylous ascites) 水臌 or the pleural cavity (chylous pleural effusion) 滲出液, because of rupture of some of these distended lymph vessels.

Gun-shot wounds of the chest may injure the thoracic duct and chyle escape. In some cases this injury will be cured spontaneously by healing of the wound.

The thoracic duct may be secondarily 次 infected in intestinal or pulmonary tuberculosis. It is often the site of secondary cancer deposits in abdominal cancer.

The *thoracic duct* has been *wounded* and chyle escaped in *operations* on the *glands of the neck*. If this happens ligature the duct and the chyle will find its way into the veins by anastomosing channels.

Cervical lymphatic glands often become infected from inflammation of mouth, teeth, tonsils, etc. If pus is formed it is apt to spread widely beneath the cervical fascia unless incision relieves it.

Cervical lymphatic glands are often the site of tubercular infection. It is essential to know the site of the various groups of lymphatic glands so that the difficult and sometimes dangerous dissection may be carried out with minimum of danger to the patient. If the jugular veins are bound up in the mass of tuberculous or cancerous glands ligate the vein above and below the mass, and remove the whole including the vein.

The Axillary lymphatic glands are often enlarged in cancer and in infection of:—

1. Upper part of back,
2. Shoulder,
3. Front of chest and mammae.
4. The upper part and front and side of abdomen.
5. Hand and arm.

In removing *cancer* of *breast* 乳腺 *all* axillary 腋 glands 腺 with fascia 筋膜 also pectoral major 胸大肌 and minor 小 must be removed en masse.

Inguinal 腹股溝 and *subinguinal glands* frequently become enlarged from infection in parts they drain, e.g. in cancer or syphilis of prepuce and penis, or labia major 大陰唇, in cancer of scrotum and lower part of the vagina 陰道 and lower abdomen, or gluteal 臀 region. The upper group is almost invariably enlarged. The lower group is usually affected in diseases of the lower limbs.

Enlargement of the *mesenteric* 系膜 *lymphatic glands* occur in diseases of the intestines, in enteric fever 腸熱症 (typhoid), tuberculous ulceration or malignancy of the bowel. These glands may sometimes be palpated through a thin abdominal wall.

Tracheo-bronchial glands are constantly receiving dust and black carbonaceous 炭的 materials. At first these are moderately enlarged, firm, inky black, and gritty 含沙的 on section. They increase in size and may become fibrous, or may break down into a soft shiny mass or may calcify 化石灰質. *In tuberculosis of lungs* these glands are usually infected. They enlarge, may soften, or become fibrous or calcify. An enlarged tuberculous lymphatic gland may perforate bronchus and discharge contents via the mouth. This is dangerous because tuberculous infection may then spread broadly.

Tuberculous infection of these glands in childhood is common. It is best diagnosed by X-ray and the enlargement is not always due to tuberculous infection.

APPLIED ANATOMY OF VEINS.

The *facial vein* is not so flaccid as some veins hence remains open when cut and it has no valves. It communicates freely with intracranial circulation via orbital and *ophthalmic veins* 眼靜脈, also by deep facial. Hence in severe infection of face, the infection may set up thrombosis 絡血結塊 in facial and clot with pus go to various parts of body including cranial sinuses.

The *Internal Jugular* requires *ligation* 結束 in severe cases of otitis media 中耳炎 with pus and thrombosis to prevent thrombosis entering circulation, especially in old cases of years standing are dangerous for clot may cause septic embolism 漂血塊塞絡 of lungs. The Internal Jugular is surrounded by many deep lymph glands, and in tuberbulosis and *Cancer* these may adhere to vein, this is dangerous. *Treatment:* ligate vein above and below the tumor and remove en masse.

An *arteriovenous* 小靜脈 *communication* may be established between the caverous sinus and the Int. Carotid artery and give a *pulsating tumor* 跳瘤 of the orbit, due to injury (bullet wound, etc.)

Caries 骨爛 of *nasal cavities* and accessory sinuses 副竇 may give septic thrombosis of cavernous sinus.

Intracranial high blood pressure 顱內之高血壓 may be relieved by leaches 蛭 behind ear, because blood is thus drawn from the transverse sinus via emissary veins 出顱靜脈 of mastoid 顳乳

Venesection 靜脈割術 (blood-letting, or *bleeding*) is generally performed at front the *elbow*. *Intravenous* medications in *syphilis* 楊梅, *malaria* 瘧症, etc. is often practised by puncturing one of the veins in front of the elbow. Also intravenous injections of *normal salt solution* and *blood transusions* 引注血術 are done at the same site, for *severe haemorhage*. *In operations in the axilla* avoid wounding the axillary vein by first exploring and dissecting carefully with dull instruments. Do not tear.

The *Saphenous* vein 隱靜脈 is frequently varicose due to long vein and erect position of man. This plus lowered resistance of vessel wall causes vessel to dilate.

Portions of *veins* are often *removed for varicosity* 膨脹.

Haemorrhoidal veins may become varicose and form form haemorrhoids 痔瘡 or *Piles* due to several anatomical reasons; -

1. Vessels are in very loose connective tissue hence lack support.

2. The superior haemorrhoidal 痔上靜脈 and portal veins 門靜脈 have no valves.

3. These veins pass through muscle tissue hence compressed by contraction during defaecation 屙糞出恭 etc.

4. They are affected by every form of portal obstruction.

Testicular Veins 睾丸靜脈 are often varicosed i.e. *varicocele* 陰囊靜脈瘀曲. It is usually on left side, because the left testicular vein joins renal at right angles. This is overlaid by the colon which when full, as in constipation, its weight impedes flow of blood.

Portal vein obstruction may produce *ascites* 水膨 or free fluid in abdomen. This may be due to:—

1. Pressure of tumor on the vein, e.g. cancer head pancreas 脃.
2. Cirrhosis of liver 肝變硬. Here the radicals of portal vein are pressed by the contracting liver tissues, hence increased pressure.
3. Valvular 瓣 disease of heart gives back pressure on hepatic veins, and hence on the whole circulation of the liver.

In ascites life will be prolonged and will have less ascites if there is good collateral circulation 間接循環 between portal and systemic circulation. This is affected by communication between:—

(a) Gastric veins and aesophagus 咽管, 食道 vein emptying into hemiazyges 半奇靜脈
(b) Veins of colon and duodenum 十二指腸 into left renal.
(c) Accessory portal system of supply, i.e. veins passing by way of ligaments of liver, e.g. via round and falsiform to unite with epigastric and internal mammary, and via veins of diaphragm to azgos. A large vein may pass by the round ligament to umbilicus 臍 and there produce a prominent varicose circle of veins called the caput 頭 medusae.
(d) Veins of Retzius which connect intestinal vein and Inf. Vena Cava.
(e) Superior, Middle, and Inferior haemorrhoidal.

(*f*) Rarely through a patent ductus venosus thus connecting the portal and inferior vena cava.

RESPIRATORY (Breathing) SYSTEM. 呼吸系統

Each cell of the body is an engine which produces motion, heat electricity, etc. They get their energy by burning fuel. To do so they use up oxygen and give off carbon diaxide, (CO_2) Each cell gives off a special product. The combustion in the body cells is slow. Heat may be given off as in muscle and liver cells, but the product often is chemical (as in glands) and nervous or electrical (as in nerve cells). Light is not produced in the human body but occurs in glow worms and some sea fishes.

The supply of oxygen and the excretion of carbon dioxide must be constant. Failure in this means asphyxiation 窒息 and death if long continued. Man does not take up O by his skin from the air. What is the spark that kindles the wet fuel in our cells to combine with O? The blood carries the O and CO_2, and the *enzymes in the cells keep the oxidation (fires) burning.*

The red cells of the blood carry O to the tissues. They contain *haemoglobin*, 血色蛋白 and substance which takes up 1 1/3 times its own weight of O and gives up 40% of this O to the capillary cells, The red cells and blood plasma take up the CO_2 and thus the constant service is kept up during life.

Where do the red cells get the O and where does the blood get rid of the CO_2? It is by exchange of air which contains 21% of O and will absorb any amount of CO_2. The skin cannot perform this service. The solution of the problem is the *lungs*. They bring O to the blood cells and in them the air takes up the CO_2. The lungs have a surface 50 times greater than the skin and their cells have air on one side and the constantly moving blood on the other side. The cells of the lungs dissolve the O and CO_2 and pass them across to their distination.

In the body the blood of the capillaries gives up O and takes up CO_2. In the lung the blood of the capillaries gives up CO_2 and takes up O. The blood goes about 3 times a minute through both sets of capillaries. In 24 hours an active man absorbs more than 20 cubic feet of O and the blood gives up as much CO_2. The respiratory surface of the lungs is about 700 sq. feet. The mechanism for change of air is like a bellows. It is automatic and self-regulating; working when we are quiet about 17 times a minute and may reach 70-20 or more times a minute in great exertion or in pneumonia. 肺炎

The stem of this bellows mechanism comprises the nose, pharynx, 咽 and the trachea, 氣管 the expanding part is the lungs. This bellows takes in and lets out the air through the one nozzle also through this same entrance and exit the air path is crossed by the food path *i.e. the mouth, pharynx and oesophagus. This cross traffic is controlled by valves, the epiglottis* 會厭 *and the vocal cords.* 聲帶 The lungs lie in the thorax much like a toy balloon in a bottle. If the air is pumped out of the bottle the baloon with its air will expand and fill the bottle.

The lungs and trachea are elastic like the rubber balloon. There is a vaccum between the lungs and the thoracic wall and the pressure of the atmosphere 大氣 (15 lbs. to sq. in.) distends the lungs flat against the walls. The lungs by their elasticity are always trying to contract. The thorax expands and contracts and thus changes its form with every breath. In the thorax all four sides contract although the upper and back part do not contract very much.

Expansion of the cavity (inspiration) sucks in air and contraction (expiration) blows out the air.

The *side of the thorax* are formed of ribs curved like a bow and in front are attached to the sternum by cartilage. The muscles attached to the ribs lift the middle of the ribs at the same time and the chest expands i.e. gets deeper.

In *movements* of the lungs the costal cartilages twist somewhat and being elastic they yield if blows occur on the thorax and thus lesson the danger of fracture of the bones.

The shoulders and arms are in man a dead weight hanging on the thorax and interfere with breathing to a certain extent. Because of this interferance man depends chiefly on the movement of the diaphragm in expending the chest. The diaphragm is a dome shaped muscle flattened on top. Its lower end is circular and is attached to the margins of the thorax and spine. Inside this dome are the liver stomach and other organs of the abdomen. When the thorax expands the diaphragm pushes down the abdominal contents and lifts up the ribs and thus makes the cavity of the thorax bigger. It also becomes dome shape and the lower edge of the lungs descend almost to the lower margin of the chest.

In taking a full breath we use many means to enlarge the thorax. We lift the shoulders, ribs and sternum by muscles from the skull and the spine; the diaphragm helps greatly. If we fix our hands and shove up our shoulders we can still more enlarge the thorax.

In ordinary breathing we take in about 1 pint of air, but, by using every accesery factor we may take in 2-3 quarts more. In ordinary of the chest (expiration). The elasticity of the longs starts it. The shoulder and arms fall on thorax and shoves down the ribs through gravity. The rib cartilages untwist and cause ribs to sink.

For forced expiration the abdominal muscles are used.

These are the ones which assist in prolonging notes in singing and blowing trumpets. The stem of the human bellows is expanded in its upper part and modified in 3 regions. The upper consists of trachea, larynx, pharynx and nose. This tube warms, moistens, and filters air when needed and makes the sounds used in talking and singing. The lining of this pipe is of epithelium, 上皮 the cells of which have moveable cilia. These sweep dust out through rose or up into the pharynx. This ciliary movement may go on 3-2 days after death. Glands keep the walls moist and dust sticks. This type of epithelium lives most of the respiratory tube.

The nasal cavity 鼻腔 extends from the mouth to the pharynx. It extends to the sides out under the eyes and upwards from the palate into the forehead in front of the brain. There are partitions of bony walls dividing the large air space into small parts and recesses. The external nose is only a small part of the nasal cavity. The walls and partitions inside the nose are cartilaginous. Blows on the nose do not always break it owing to elastic cartilage.

In the mid-line of the nose is a partition from the brain case above to the palate below dividing the nasal cavity into two parts. Other partitions incompletely seperate the nasal cavity from its recesses. The *recesses* are one big one under each eye (antrum of Higmore), 上顎竇 three smaller ones on either side, one big one in the forehead (frontal sinus) and another large one extending up and back into the base of the skull (ethmoid sinus). 篩竇

These recesses or *sinuses* make the bones of the skull lighter. They are subject to infection from the nasal cavity. The air of these sinuses and recesses keep the nasal cavity warmer. The entrance to the nasal cavity 鼻腔 (the vestibule) is 1/2 inch long and is lined with skin having short coarse hairs. These filter dirt and some bacteria from the air. From the vestibule the air goes to the main cavity. The roof and upper walls of this part constitute the area for small (olfactory). The epithelium there has no cilia and the cells react to odours. These cells are directly connected with the brain. Glands surround these cells and substances borne hither are dissolved in the secretions of the gland and the sense of smell results. On the sides of the nasal cavity are 3 shelves called the *turbinate bones*. 鼻甲 They are thin bone and have curled edges and are covered with blood vessels to warm the air as it passes. Some animals in cold countries have as many as 7 turbinates. Only 2 of man's 3 are well developed. Tears run from the eyes to the nose through a duct on the side wall. Because of the great area of the nasal cavity infections of the nose make much discomfort and if they extend to the sinuses and recesses there may be very serious complications of eye, brain, ears or teeth. The nasal cavity opens into the upper pharynx.

The *upper pharynx* is connected with the tympanic cavity of the ear through the *Eustachian* tube. 耳咽管 Thus the air pressure on both sides of the tympanum is equalised. The cartilage of this tube keeps it from collapsing.

In the upper palate is the soft palate with the *uvula*, 懸雍垂 a soft valve curtain which shuts off the nose when one swallows. The pharynx is a food as well as an air way. It has no cilia on its epithelial cells but they are tough and thick as is the mouth epithelium. The *larynx* 喉 or voice box opens into the lower pharynx. The vocal part is formed by changes in shape of the air tube. The cylinder like tube narrows to a slit formed by the *vocal cords*. 聲帶 These are elastic ligaments covered on the inside with flat tough epithelium. There are no cilia on this epethelium. Above the cords is the *vestibule* 前庭 of the larynx. This cavity with its air contents gives the cords a chance to vibrate and thus produce different notes when the air, controlled by slits between the vocal cords, is blown into it.

Above the vestibule is the *epiglottis*. 會厭 The cavity of the larynx consists of 3 chambers, one is below the vocal cords, the middle one called the *ventricle* 室 is between the true and false vocal corda and the uppermost is above the false vocal cords.

The false vocal cords, or properly the *ventricular* folds, are 2 flaps which project down and inwards, the edge of the is the false vocal cord. These are above and parallel with the true cords. The false cords contract to prevent air from going in. The uppermost chamber, is celled the vestibule. It can be completely closed by muscles as in swallowing and at that time the epiglottis is drawn down so it covers the closed vestibule.

The epiglottis is shaped like a roof sloping from the midridge to the sides. It is attached only at its anterior edge and it opens and close as a valve for swallowing.

Vocal cords can be approximated or separated by muscles. They are 1 inch long in man, and 3/4 inch long in woman and children (thus the higher pitch of their voices). They are attached in front and behind to cartilages which are moveable by muscles. The *arytenoid cartilages* 披裂軟骨 at the posterior ends are especially moveable and it is by action on them that the muscles affect the cords and therefor makes the pitch of the sound. The purely individual quality of a persons' voice are added in the throat and nose.

When food touches the larynx we swallow at once. It is automatic and not under control of the will. It involves all the muscles of the pharynx and most of the larynx.

The air path is under our control for a time. We can sing or talk as we please and hold our breath for about a minute then we forced to breath whether we wish to or not.

The *trachea* 氣管 is about 4 1/2 inches long and nearly 1 inch wide. It is reinforced by 16-18 bands of cartilage. These are incomplete behind and the gap is filled with muscle.

The cartilages prevent collapse of tube on suction and the muscles narrow the tube to lessen amount of the air intake or to give force to the air blast in coughing etc. There is much elastic tissue between the epithelium and cartilage, because the trachea must stretch when the larynx or lungs move.

The *thorax* 胸 is divided into right and left halves. The median partition is composed of the heart and great vessels and the vertebral column. Each side of the thorax has *ribs* 肋骨 on its sides, the *diaphragm* 膈肌 below and the partition in the middle. Each side is lined by a closed sac called the *pleura* 胸膜 closely applied to all the walls.

In the embryo the trachea has two buds which grow out from the middle partition against the inner wall of the sac of the pleura. These are the right and left *lung buds*. As they grow they shove in to the pleura and become covered by it. They are quite small before birth but when the new born child takes its first breath they expand. The pressure of the air distends them to their limits and fill all the space in the sides of the thorax.

When we breathe and twist our bodies the thoracic cavity changes in shape and extent and the *lungs* change to exactly the same extent. The lungs are extensile and elastic and are always stretched to their limits by the pressure of the air. The lungs serve for the exchange of O and CO_2 between the blood and air. The exchange needs an enormous surface. The lungs do this through the office of tiny balloons, each connected with the air way. These are like grapes on their stem. Each balloon is about 1/125 inch in diameter. These grow from birth to mature age. There are 300,000,000 of them in the lungs. Their aggregate surface is more than 700 sq. feet. There is only space between them for tracheal branches and blood vessels. Their business is to bring air and blood capillaries together. These balloons expand and contract with the chest movements. Some anatomists say their walls are only a delicate network of elastic fibrils. There is a thin layer of fluid inside this wall in which 0 and CO_2 are dissolved and exchanged. Capillaries surround each balloon and these walls are only 1/300,000 of an inch in thickness. Great speed is characteristic of exchange of C and CO_2 as the as the blood makes a complete round of the whole body in 28 seconds.

If enough CO_2 is not taken away the contammated blood goes to the brain to a control station which speeds up the breathing.

The fine and large branches of the trachea or air-way are elastic but cannot collapse 萎 for they also possess cartilage. The ciliated cells of the mucous membrane which are defences against dust and bacteria, etc., extend down to branches 1/25 of an inch in diameter, after that there are no cilia. If the dust and bacteria reach the balloons they are attacked by phagocytes which eat them up and carry them to the lymph vessels. (See lymph vessels.)

The air tubes also possess plain muscle fibres even to the finest twigs. This regulates the amount of air. It may shut off the twigs entirely as happens in asthma 哮喘 when one may only, be able to use 1/20 of the lung tissue because of the spasmodic contraction of the muscle fibres and the consequent closure of the balloon. The tiny balloons are massed in groups in irregular shapes. When the lungs are expanded to the fullest extent the air tubes will separate like the leaves of a fan and this allows the balloons to expand. They cannot expand unless there is the deepest breathing. If they are not used they become degenerated and diseased. All children and adults must use their lungs to the fullest extent several times a day to ensure better health.

The right *lung* is bigger than the left one and is also in more direct line with the trachea; hence more dust and germs enter it. Pneumonia affects the right lung 10-7 as compared with the left lung. The lungs are divided into *lobes* 葉 three on the right and two in the left sides. The lobes are separated by infoldings of the pleura. The pleura secretes a fluid which facilitates lung movements. Without this fluid friction would occur and pain result. In inflammation of the pleura in the first stages of it the pleura is dry and "friction rubs" are heard. Thus pain is caused. In full expansion of the lungs the upper lobes move forwards and the lower lobes move downwards. The left lobe is a cushion adapting itself to the constantly moving heart. Both lungs accommodate themselves to the movements of each other.

THE ALIMENTARY CANAL. 消化道

The alimentary canal supplies the body with food and oxygen and excretes some waste products. The alimentary canal is a muscular tube lined with essential mucous membrane of different kinds and functions. It extends from the mouth to anus and occupies, except in the abdomen and thorax, approximately the mid-line of the body.

The alimentary canal opens to the surface at both ends, the mouth and the anus. In the earliest embyonic life it is closed at both ends. The alimentary canal is divided lengthwise at both ends for varying distances. Structures which, in developement, break off from it at the head end, become the nasal cavity, the trachea, and the lungs. The function of these is to take in oxygen for production of energy and throw off the waste gas, CO_2, and moisture. The tube at the anal end is split, in developement, into the rectum and the urinary bladder 膀胱 and urethra, These carry off waste products from the bowels and the kidneys. All the rest of the tube is the food canal. It includes the mouth, pharynx, 咽 oesophagus, 食管 stomach (fore-gut), small intestines 小腸 (mid-gut) large intestines 大腸 rectum 直腸 and anus 肛 (hind gut).

Food which is to be digested and assimilated and transported to the blood must first be made fluid. The alimentary canal transforms, in a relatively short time, all food into fluid like the blood lymph. The teeth break, bite and chew the food, the tongue and the muscles of mastication assist in the process; it then goes to the stomach and is ground up into small divisions, it is there digested in part and made fluid; the fluid food is further digested and absorbed from the intestines, and, finally the unabsorbed residue is brought together and thrown away from the body through the anus. In animals the alimentary canal does all these things, in man he is assisted by his hands and by preparation of the food before it is eaten. The food changes are carried on in various parts of the alimentary canal and progresses from the mouth backwards. Each part is specially prepared for its own functions. The mouth, sucks, bites, tears, chews and mixes; the pharynx swallows into the oesophagus, which carries food to the stomach through the thorax; the small intestines digest and absorb; the small intestines digest and absorb; the large intestines slightly absorb and separate undigested residue away and casts it off.

There is a uniform plan of structure, the mucous membrane is the innermost layer, outside of this are layers from the ventral mesoderms as follows the submucous connective tissue; the muscle layers, and in the abdomen another layer, the peritoneum. 腹膜 The body wall ends at the top of the neck but the alimentary canal extends above the body walls of thorax and neck into the head. There are, in the head, great modifications of the alimentary canal these are the mouth, nose and pharynx, which part of the head is in front of the brain and composes the lower part of the head.

The skin is depressed into nose and mouth and becomes continuous with the mucous membrane of the foregut. The alimentary canal opens to the skin at the nasal and buccal cavities. Both of these are lined with skin in front and mucous membrane behind. Around them the ventral mesoderm extends, (but the head is not hollow, that is, contains no body cavity). The connective tissues about the cavities are chiefly shaped bones (upper and lower jaws and hyoid). The muscles in front of the head from the ventral or gut mesoderm are the jaw muscles for biting and chewing as well as the muscles of facial expression and the pharyngeal muscles used for swallowing. All these muscles are formed in the wall of the alimentary canal; they are really gut muscles, even though some contain cross striped fibres.

The extent and boundaries of the mouth are as follows. The mouth cavity has for its roof the palate, hard and bony in front, soft, muscular and moveable behind. The palate separates the nasal and buccal cavities in mammals but not in other animals. It occurs only in those animals who suckle their young. Both cavities open behind into the pharynx. The pharynx has a nasal and a buccal 頰 portion. The soft palate is a valve between them and entirely separates them when it is in apposition with the posterior wall of the pharynx.

The pharynx also has a laryngeal 喉 portion, it can be shut off from the larynx by the epiglottis. 會厭 It opens for breathing and closes for swallowing. The floor of the mouth is almost entirely formed by the tongue, a large mass of muscle covered by mucous membrane. The tongue is a muscle of considerable size. Above the base of the tongue the mouth cavity opens into the middle part of pharynx. This area can be completely closed through the action of the soft palate and tongue against the posterior surface of the pharynx. This opening is closed in sucking and opened in swallowing. The lower pharynx opens into 2 tubes. (1) the oesophagus 食管 and the (2) larynx and trachea. 氣管 Food from the mouth goes via the first route and air via the 2nd route. The air and food passages cross in middle pharygnx like an X. Skin lines the anterior part of mouth and it forms the lips and teeth. On the posterior part of the red area of the lips near the centre the papillae 乳頭 of the skin are long hence the lip is rougher at that site.

New born mammals have these papillae at birth probably for sucking, but they disappear in a few weeks. The teeth are formed in the skin not the jaws. The bone grows around them after they are formed. Some fish for example, sharks (see museum specimen) have teeth all over their mouths. These teeth are all sharp and pointed. In reptiles (see snake in museum) teeth are pointed backwards hence a snake cannot let go anything it has commenced to swallow. Humans have two rows of teeth germs, an outer and inner row. Both rows are curved and parallel to each other. The outer form the milk teeth the inner the permanent teeth. No mammals regularly and normally have more than 2 sets of teeth, an occasional person has a 3rd set in old age.

Permanent teeth; We have on each side in each jaw 2 incisors 門齒 (cutting) one canine 犬齒 (tearing), two premolars, 前臼齒 and 3 molars 臼齒 (grinders) i.e. 32 altogether. Each tooth is crowned with enamel (the hardest substance in the body. It comes from a gland like ingrowth of the skin (outer layer of ectoderm) and is deposited on the tooth before the tooth breaks through the jaw, then the gland like body disappears, no more enamel 琺質 is deposited thru life. If the enamel is worn thru the dentine is exposed.

After 40 years the enamel is usually worn off the tips of the incisors, after 50 it usually is off the canines. The rest of tooth is made by the connective tissue inner layer of skin, corium, it is called *dentine*. 齒質 This is chemically like bone but its fibres are differently arranged. The body and roots of a tooth are hollow. The central cavity has blood vessels and nerves which enter at the root tips. The substance which attaches the roots to the socket of the jaw, looks like true bone but it comes from the skin not the jaw bone.

Every tooth of each jaw bites against 2 teeth in the other jaw exept the lower medial incisor. The canine tooth is said to be a part proof of man's relationship to lower animals. Molars (upper) have 3 roots, lower, 2 roots, all other teeth one root. The 3rd molar sometimes never erupts. It is said to be disappearing in the process of evolution, therefore the jaw is shortening. The 3rd molar is often impacted against the 2nd molar.

The mucous membrane of the mouth pharynx and oesophagus is thick, tough and strong because food is rough before digestion. It consists of many layers of cells—10-20. It looks like the skin and has been called "mucous skin" Over the upper surface of the tongue are thousands of papillae of large size. These give the tongue its rough surface. These papillae are of 3 kinds —1 *filiform*, 絲狀 these have a horny fringe and have a direction backwards. They are used in licking and are especially developed in cattle, and in cats even more so, so that they are quite a weapon in felines. Human beings have some of these segregated in the conical papillae, food and bacteria may lodge and the latter incubate there. Less numerous but larger are the (2) *fungiform* papillae. 菌狀乳頭 These have moats around them called the *papillae vallatae*. 輪廓乳頭 They are arranged in western peoples mouths in an invertedmanner: in Chinese, Mongols and Africans the arrangement is an inverted Y.

Taste buds are found in the fungiform papillae. Just behind the furthest back of the walled papillae in the mid-line is the *foramen caecum.* 盲孔

The thyroid gland grow off the mucous membrane of the tongue at this point. The pit is the stump of the stalk. Behind the pit the mucous membrane of the tongue is full of little rounded masses with a central pit, these are called (3) *lenticular papillae.* 豆狀乳頭 They are full of little white cells identical with those in the lymph. This structure is like the tonsils and this area at base of tongue is called the *lingual* 舌 *or tongue tonsil.* In the mucous membrane of the mouth are many thick cells that secrete saliva through ducts. An ordinary man secretes 1½ quarts of saliva a day, a cow about 15 gallons. There are thousands of glands about the mouth. The under surface of the hard palate has many of them. Four large secreting glands conected with the mouth are viz:—the parotid, 腮腺 submaxillary, 頷下腺 sublingual 舌下腺 and the anterior lingual under the tip of the tongue.

These glands are often far away from mouth cavity and therefore have long ducts. The duct of the parotid opens opposite the 2nd molar tooth of the upper jaw. The submaxillary and sublingual open one on each side of mid line under the tongue. The finer structure of these glands must be studied in histology. Some cells secrete mucus other secrete a ferment. The parotid does not secrete mucus but ferment. Everywhere on the upper surface of the tongue are glands (small) under the mucous membrane some of which secrete ferment others mucous. Mucous lubricates the mouth and food. The ferment fluid flows out and washes the crevices etc of the tongue surfaces, it washes away substances that stimulate the taste buds so they rest and recuperate and it also prevents bacteria from growing in the clefts, etc. In some sicknesses these glands are not active hence the tongue is coated. The ferment of the saliva is called ptyalin, it converts starches to sugars. Most of the mass of the tongue is muscle, the fibres of these run in all directions. Some of the muscles arise from bones nearby, especially from the hyoid, other muscles are entirely in the tongue itself and not attached to bone. All the muscles are inserted into the connective tissue below the mucous membrane, this connective tissue has many elastic fibres, so the tongue always tends to the return resting position and form. The tongue is very actively used in chewing, talking, sucking. Only mammals can suck, for example, a horse drinks with head down but a hen lifts it head to drink. Man's and mammals have a relatively small throat which necessitates the food being chewed into smaller masses than need be done in lower vertabrates. 脊椎動物

From the mouth the food passes to the middle and lower pharynx and to the oesophagus and thence to the stomach. Between the stomach and the mouth the oesophagus is for transport only. The pharynx transports food and air. The parts that carry air are outgrowths from the pharynx-these parts are the nose, upperpharynx, larynx, trachea and lungs. These will be described under respiratory apparatus. It is approximately 16 inches from teeth to stomach. the oesophagus is about 3/5 inch in diameter. The mucous membrane from teeth to stomach is practically of the same structure. The oesophagus has a modified structure for protection in swallowing, it is tough and strong, extensible and adjustable. There are many glands associated with the mucous membrane. It also has masses of lymph cells like those of the lenticular papillae of the tongue. The throat or fauces is the narrowed middle pharynx. The roof of the throat is the soft palate and the floor is the base of the tongue. In each side of the fauces are two vertical folds in between which are the tonsils., this is found only in mammals. These muscular folds can be brought together, and, acting in conjunction with the soft palate closes off the throat completely, so that even air cannot enter, The uvula is the tag which completes the closing. Close throat and lips, draw down tongue and there is a sucking motion. Birds, repliles and fish cannot close their mouths (only mammals can do so) and therefore cannot suck.

The tonsils are masses of lymph cells under and invading the mucous membrane. There are deep pits in the tonsils, warm and moist and there the bacteria live and multiply—from there disease may spread all over the body—the tonsil is one of the ports of entry of disease into the body.

Pharyngeal tonsil. 咽扁桃體 High up on the posterior wall of the pharynx is another area infiltrated with lymph tissue. It is called the pharyngeal tonsil. It is well developed between the age of 2 and 12 years. When infected it becomes enlarged and the resulting masses are called *adenoids.* 增殖腺

Glands secreting mucus are abundant in the pharynx but scarce in the human oesophagus. In other mammals mucous and ferment forming glands are found in the oesophagus—the dirtier the food the more are the glands. Hence pigs and dogs have more than horses and cats. These glands probably destroy and wash bacteria away.

The embryonic alimentary tube is made up of mucous membrane only. If contains no blood or lymph vessels, no connective tissue nor bones. These are all added by the ventral or intestinal mesoderm. The epithelium 上皮 is the all important layer. It lines the tube and it alone comes in contact with the food and digests and absorbs it. This layer forms some salivary 涎 and all other glands of the intestines and has next to the ectoderm the most various and important potentialities of any tissue in the body. In the head and neck it gives off the lungs and eustachian tubes 耳咽管

it also gives off some glands whose secretions go directly to the blood stream. These are glands of internal secretion which bud off from the pharynx e.g. the thyroid, 甲狀腺 parathyroid 副甲腺 and thymus. 胸腺

In the muscular coat of the intestines is the muscle of the mucous membrane called the muscularis mucosae. Its function is to readjust the mucous membrane when it is pulled out of place as when a spicule of bone is swallowed. The glands and larger lymph nodules extend through this muscle in the oesophagus. Outside of this coat is a layer of loose submucous connective tissue with many elastic fibres, blood and lymph vessels and nerves. This loose tissue allows the mucous membrane to expand to the size and shape of the object swallowed outside of this again there is a thick muscle coat in two layers, an inner circular and outer longitudinal layer, which is characteristic of the walls of the alimentary canal from the pharynx to the anus.

When food touches the inner surface of the intestinal mucosa then an automatic process, regulated by the nervous system, occurs, the circular muscle below the spot relaxes and above it contracts. Thus the object inside is carried downwards in and a wave of contraction of the circular muscle follows it. The outer longitudinal fibres help pull up the intestinal wall over the mass as it is forced along. *This process is called peristalsis.* 蠕動 In the intestine stomach and lower parts of the oesophagus the process is slow, while in the mouth and pharynx the process is rapid.

Around the mucous membrane of the mouth and pharynx not only is there muscle but also bone and cartilage. The upper and lower jaws are formed by the mesoderm and enclose the upper end of the intestines. Somewhat lower down is the tongue (hyoid) bone and the series of cartilages of the larynx. This series suggests the successive bony arches of a fish's pharynx with jaws and gill 鰓 arches.

In the human embryo the throat and neck are like those of a fish—the same bones being present in the same order. The muscles are arranged in arches around the bones. There is a series of gill clefts between the gill arches. The fish breathes by the water which goes in and out these spaces. In the human respiration is different. The bones remain but the clefts disappear. But there are pouches set into each and the skin sends in depressions to meet the pouches. Some of the pouches persist in the adult. The first cleft is the ear canal and the eustachian tube comes to meet it. Another gill-cleft pocket is around the tonsil and a third and fourth become separated off from the pharynx and become the parathyroids and the thymus. The thyroid grows from the front of the pharynx at the base of the tongue and not from a gill pouch. Our ancesters continue to live in us.

The muscles of the pharynx do not preserve the original gill arrangement. Some grow together and some spread out. They are broken up into many parts with special functions. This is inevitable because of the many functions of the pharynx and mouth-sucking, biting, swallowing breathing, talking, expressing emotion value movements (soft palate and epiglottis). All these are produced by intestinal muscle from pharynx.

Many of the movements are sudden and sharp and must follow one another in perfect coordination as in swallowing—Speed is essential. The valve like movements of the soft palate are produced by two muscles arising from the base of the skull. Below them and superficially placed are two others arranged like an inverted Y which are attached to the skull and lift the tongue and larynx in swallowing and pull up pharynx over the bolus of food which is going down. The muscles of the *tongue* are not of intestinal origin but are body wall muscle.

The part of the alimentary canal in the abdomen is about 28 feet long. It changes all kinds of food into fluids which go to the blood and lymph for fuel on building material to the body cells.

This process is called digesation, 消化 absorption 吸收 and excretion. 排洩 It is a great chemical laboratory which does its work in 36 hours or less. The alimentary canal is automatic and works night and day but not always at the same rate. Chemicals are required and manufactured as needed. This canal contains ring valves which expand or contract. It has an automatic electric signal and forwarding system, a warehouse and a postal service, a police force and scavengers.

This canal is a long tubular factory. Its main parts are the stomach (11 inches long); Small intestines (23 feet long) with liver and pancreas, large intestines (5 feet long), and, rectum (5 inches long). One general style of architecture runs through its whole length. Inside is the epithelium, then a loose connective tissue with muscularis mucosae; then, the inner circular and outer longitudinal muscle layers. All are held together by an envelope of connective tissue.

Two important features are 1. the inner epithelium is thin—only one layer of cells 1/1000 of an inch thick, which while in the mouth and oesophagus there are 12—15 layers of cells. 2. Outside of all the coats is a smooth, shiny slippery peritoneal membrane surrounding everything and attached to the posterior abdominal wall. The upper part, the stomach and 5 inches of the small intestines is also attached to the anterior wall. This slippery surface permits free movement.

The stomach 胃 is a digestive sack in which the food *remain about 4 hours. It is 11 inches long, 4 1/2 inches wide* and weighs 4 1/2 ounces. It can hold 1 quart of contents. It is moveable. Its position varies greatly as also its shape.

It upper half is wider than its lower half. It received food on it right side. The first food received spreads out all over the mucous membrane; later foods go to the centre and do not reach the mucosa for some time. No matter how distended the stomach is, its surface is covered with the mucosa. The mucosa is ordinarilly (empty) wrinkled and folded. It is a layer of cells 1/700 inch thick. This mucosa is not all flat membrane but dips into the underlying pits or well like test tubes. These are the glands of which there are about 25,000,000. This gland layer makes the mucosa about 1/25 inch thick. Three or four glands open into one pit, and there the gastric juice and chemical interaction of several gland products occurs. These deep pits are really chemical retorts *making HCl, pepsin, rennet and mucus*, and pour them out automatically when we see, taste or smell food. These glands secrete as long as there is food in the lower part of the stomach.

The main function of the stomach is the digestion of protein or nitrogenous food and it is a slow and complex process. First it is treated with HCl and ferment and later with ferments without acid. The food becomes a fairly fluid mass *(chyme)* 食糜 and is then passed to the small intestines for further treatment. Little H_2O is absorbed in the stomach but is passed furthur along the canal. Some foods, alcohol and sugars are absorbed from the stomach. Outside the epithelium is the loose connective tissue filling the space between the glands and carrying the blood and lymph supply and the nerves—the latter are the telegraph electrical system delivering messages from the brain.

Stomach muscles are strong. The coats are an inner circular and an outer longitudinal and an additional oblique layer in its upper half. The circular fibres are especially thick at the openings of the stomach. The upper ring or valve at the lower end of the oesophagus is usually closed and opens when food arrives. This is an automatic action through nerve control.

Food goes through the pharynx and oesophagus very rapidly-a fraction of a second. It is held up 2—3 seconds at the ring. This ring closes to keep stomach contents in, if it did not our food would regurgitate into our mouths. Sometimes it does—in vomiting. Messages from nose or mouth (badsmells or tastes), brain, from stomach itself, from inner ear (sea-sickness), uterus (vomiting of pregnancy) and many other parts will cause this gate to expand and vomiting often follows if messages are sufficient and continuous.

The stomach opening into the intestines is called the *pylorus.* 幽門 It is a thickened circular muscle valve, the strongest and most tireless in the body. Pressure will not open but close it more firmly. Only when the fluid and acid content of the stomach contents is right will it open. It opens rhythmically from time to time and allows the liquid acid content through.

The lower half of the stomach is the most active part. Its circular muscles contract vigorously. A wave of contraction from its middle to the pylorus passes every 15—20 seconds. These waves churn and mix the contents with pepsin and acid. The movements are automatic but are influenced by the brain. Anger, fear, worry etc. retard them while cheer and joy accelerate them. These contractions on an empty stomach cause hunger sensations.

The upper part of the stomach is a reservoir of food and gas. It acts as a cushion for the lungs. In digestion, the central part is filled with the last part of the meal and remains alkaline for a time from the ptyalin 涎酶 of the salivary glands of the mouth.

The small intestine 小腸 is the most important part of the alimentary canal. It is 23 feet long and 13/10 inches in width. Its capacity is 3 quarts. It digests and absorbs food and stores temporarilly what is not immediately needed. Digestion is more active in the upper, than the lower part. Absorption goes on in its whole length. The *liver* 肝 is the warehouse. and is an extension of intestines connected with it by the bile duct. The duct of the *pancreas* 膵腺 enters the intestines with the bile duct.

The small intestine is arbitrarily divided into 3 part— the duodenum 十二指腸 (11 inches), the jejunum 空腸 (8-9 feet), and the ileum 廻腸 (13-14 feet), The duodenum is fixed, all the rest is moveable. The food passes through this canal at the rate of one inch a minute. The epithelium digests and absorbs food. The length of this canal is to give a large surface for these duties, and is 4 times the height of the person. The surface is increased by circular folds and villi. There are about 900 of the former, and 20,000 of the latter (to a square inch).

Food enters the intestines towards the end of its digestion. The protein is nearly all digested. Its presence causes its chemical retorts to pour out their products. These are mucus and enzymes. The later are of colloidal matter and break up the food into absorbable substances. The enzymes come from glands of which there are about 4,000,000. These enzymes act on proteins, fats and carbohydrates. These glands are not sufficient for their job so they are assisted by the pancreas and liver.

The *pancreas* and *liver* are enormous glands, which furnish more than a pint of chemicals daily. This fluid enters the small intestine near its beginning and so acts on the mass of food. The pancreatic fluid helps digest proteins, fats and carbohydrates, the liver digests fats. Food in the intestine cause the pancreas to give up *secretin*. This is a *hormore* and acts an the food as a chemical digestant. Absorption is effected by the intestinal cells and those on the villi. The cells of the villi 絨毛 are a living sieve for liquids. There is a power of choice in the cells, some substances go through and others do not. The passage is through the cells not between them. All kinds of substances swallowed are in the bowel. Some of these would be poisonous if absorbed. But in life the cells of the bowel and villi protect us from injury and, or, death. This layer of cells is not always healthy and efficient and may become the portal for disease especially the degenerative diseases of advancing age. A little indigestion for years, a little seeping through of noxious fluids means a cumulative effect and the arteries are hardened (sclerosed), the kidneys injured and the spinal cord diseased.

These absorbing cells are attached to the loose underlying connective tissue and spaces exist between those attachments. These spaces are continuous and form a fluid system into which the cells pass the fluid food they have absorbed, proteins are broken into simpler molecules; fats changed to water; soluble fatty acids and glycerine and carbohydrates into some form of sugar. From these spaces the blood and lymph capillaries take up the food and carry them to all cells of the body. There are other cells in the intestinal mucosa. Goblet cells secrete mucus for lubrication of the food. There are lymph nodules especially large at its lower end. In them lymph cells grow up and become wandering cells. These lymph nodules are police and scavenger messengers. Salts of metals injected hypodermically are excreted largely by the bowel.

Waves of peristalsis move the food along in the intestinal canal. The muscle coat of the bowel is strong especially in the upper part. The waves are intermittent and move food only a little at a time. Between the waves local contractions churn the food and break it into small masses. Thus the food is mixed with the digestive juices. The outer *peritoneal coat* is smooth and slippery and permits the coils of the bowel to move freely on each other without friction. The *large* *intestine* is the third part of the bowel. Only reptiles, birds and mammals have it; fishes and amphibians do not have this organ. It is the large fermenting vat of the human factory. It handles relatively indigestable residues and requires time to do it. Food and its residue remains in it 10-48 hours. It is 56 inches long and has a diameter of 3 inches at its commencement and 1½ inches at its termination. It has ascending, transverse and descending portions, with two bends, the hepatic and the splenic.

In the large intestines the remains of the food which was unassimilated, is broken up by bacterial fermentation. These foods are chiefly carbohydrates and the bacteria make sugars of them. These are absorbed before the swarm of bacteria can eat them up.

There is a valve where the small bowel enters the large bowel (colon), this controls regurgitation. This opening is on the side and not at the end of the colon. The blind terminal portion of the colon is called the *caecum*. 盲腸 This portion contains "mother" bacteria. When the ascending colon passes on the food not all the bacteria go but many remain as "mother" for the next consignment of food.

The colon has small glands but no villi. The absorbing cells take up water and sugar readily. The muscle coat of the colon is peculiar in that it has 3 longitudinal narrow ribbons throughout its whole length. The circular coat is continuous. The contraction of the long strips produces a series of pouches between the ribbons. The food entering the caecum is fluid but absorption of the water soon makes it a paste. This fills the pouches and the circular fibres churns it up so that the fermentative action can readily occur. It takes from 12-48 hours for the food to travel through the large bowel. When the stomach receives food there is a nerve message sent the colon and the food moves along from one of its three parts to another part.

The *rectum* 直腸 is at the end of the descending colon and receives the residue passed on to it. The mass of faeces in the rectum sets into action a "touch button" nervous mechanism which sets the muscles of the descending colon, the rectum and the abdominal wall into motion and at the same time relaxes the circular sphincter of the anus to relax and thus there occurs *defecation*.

The *lymph vessels* 淋巴管 are described under lymphatic system. They carry away most of the fat and discharge it into the veins in the neck. Every vein from the bowels goes to the liver and carries there the protein, sugar and starchy foods absorbed from the stomach, small bowel, and large bowel. The sugar is stored in the liver and is given up to the veins as needed for the cells of the whole body. The liver is the living storehouse of the body in which some final changes occur to make the food assimilable and wholesome.

ORGANS OF EXCRETION.

There are 27 million million cells in the body, which live, eat work, constantly die and disappear. Food for the cells is obtained through exidation by the action of enzymes. 酶 Waste products are produced, e.g. CO_2, H_2O and certain mineral salts. The blood carries food to the cells and waste matter from them.

Cells die and are eaten by phagocytes 噬細胞 and are transmitted via the lymph to the veins. Food eaten is digested and absorbed from the intestines and thence goes to the blood. Cells will only accept sufficient food for their activities. Excess fat and carbohydrate food may be absorbed and stored up as fat but proteins of the food are not stored up. Proteins and bacteria and their products in infectious diseases must be eliminated.

The *blood* is marvelously constant in composition. Waste products do not accumulate in it. The constancy and purity of the blood is maintained through the excretory organs. These organs are the skin, lungs, alimentary canal and kidneys.

The *lungs* eliminate things that are vapourised. Most of the CO_2 and 1/9th of the total H_2O excreted goes off by the breath. Alcohol, camphor, creasote, balsam, chloroform and ether are samples of drugs eliminated by the lungs.

In the *skin* are many sweat glands. 汗腺 Each gland is a coiled tube surrounded by blood capillaries. Water (sweat) is taken from the capillaries to the tube and excreted. Other substances held in solution go with the sweat. Bromine, sulphur, lead, mercury, arsenic and iodine are excreted in this way. About 1/4 of the H_2O excreted from the body is carried off through the skin.

In the *alimentary canal* 消化道 cells of the blood and lymph capillaries easily take up food in solution and the reverse process is also possible and substances from the capillaries are excreted in the faeces. Lime, phosphates, iron salts, bismuth, copper and aluminum are thus excreted. Moreover insoluble substances may be carried by phagocytes through the capillary walls into the intestines and be thrown out. Perhaps this function explains the masses of these cells in the tonsils, 扁桃腺 Peyers patches and vermiform appendix. 闌尾 The intestines play an important part in excretion.

The main organs for *excretion* are the *kidneys*. They take soluble substances in solution in the blood and throw them out in the urine. The amount excreted varies greatly in health. They are a chief apparatus for keeping the blood uniformly constant in content.

The units of the kidneys are the kidney tubules or nephrons. They somewhat resemble sweat glands. Each kidney has about 1,200,000 nephrons and their total length in an adult man is about 75 miles (225 li). They are long but exceedingly fine in calibre. Each is entirely surrounded by capillaries and a constant interchange of fluids goes on between the nephrons and the blood capillaries. The nephrons deliver fluid to their collecting tubule. The nephron is of 4 parts. At the end each is a small ball 1/200 inch in diameter. It is a cup with double walls, the inside of which is filled with blood capillaries. It is called the *capsule of Bowman.* 球囊 The capsule is connected with the 2nd part a much convoluted smaller calibre tube of a U shape and about 1/200 inch in diameter in its descending limb; the 3rd part of the long U shaped loop is the ascending thicker tube which passes into the 4th part. This 4th part passes over and encloses its own capsule and joins a second convoluted tube which passes into a collecting tubule, the terminal twig of the collecting tubules. The nephron is the excreting agent.

Each of the 4 parts of the nephron has a special function. Part 2 excretes *urea* 尿素 and other waste products. Urea is the end product of the breaking down of protein foods on body tissues. Some of the substances excreted are poisonous, and, if much is left in the blood, uremic poisoning results and death. Part 2 also reabsorbs some of the soluble substance and H_2O; but parts 3 and 4 do more reabsorption and in the latter the final adjustment of fluid balance between the blood and urine is completed and the normal fluid composition of the blood is maintained. Of the 12 quarts possibly excreted by the corpuscles all but 3 pints are reabsorbed. This is the normal output of urine per day for an adult man.

The collecting tubules are likened to bush stems, the leaves of which are the nephrons. The nephrons are arranged in from 12-18 groups, each containing about 80,000. This group is called a *renal pyramid*. The end of each nephron joins the end of a twig of the collecting tubules. The nephrons and collecting tubules have a different embryological history. They become connected late in foetal life. The collecting tubes are arranged like a shrub with 10-25 stalks each extend up. These spread somewhat and branch till there are 80,000 terminals. To each is attached the nephron. These with the tubes and loops are ramidal in shape and is called a *renal pyramid*. 腎錐體

A pyramid with its nephrons is a *lobe of a kidney*, of which there are 13 to 18. Between the lobes the arteries and veins run from the hilus of the kidney and give off branches to the nephrons. The interior end of each pyramid is composed of collecting tubules. The outer bigger part of the nephrons is called the labrynth or cortex of the Kidney,

The lobes of the human kidney are not separated from one another. Each is distinct as a bush in a clump. The blood vessels are between and the lobes seem to run together. The lobes have no fibrous capsule and do not move on each other as is the case in some animals. The human kidney is enclosed in a single fibrous capsule.

At the apex of each pyramid (papilla) from 10-25 collecting ducts which open through as many small foramina, The urine discharged from them is received into one of the 18-20 funnel shaped ends of the ureters. The ureters are the two ducts, one from each kidney which carry the urine to the urinary bladder. *Their enlarged upper end is the pelvis of the kidney.* Each ureter is attached to the surface of the pyramids. In front and behind the pelvis the arteries and veins enter the kidney and branch between the lobes.

In the embryo the kidneys lie in the pelvis. During foetal life they ascend to their adult site where they lie on each side of the vertebral column in front of the 11th and 12th ribs downwards to the 3rd lumbar.

Each *ureter* 輸尿管 is one foot long and 1/5 of an inch wide. The urinary bladder stores the urine and from time to time discharges it. This bladder holds from 1 to 1 1/2 pints. The walls of the ureter have an inner mucous layer and an outer muscular coat. In the ureter the mucous layer is mesodermal in origin, in the bladder it is endodermal. In both, the mucosa is of several layers the cells of which slip sideways on each other on distension of the bladder and become flattened with pressure.

The muscle coats of the ureter are in two layers, an inner longitudinal and an outer circular-the reverse of the arrangement in the intestines. The long fibres widen the canal and the others force urine by waves of contraction to the bladder. Stones sometimes form in the pelvis of the kidney enter ureter, block it, and waves of contraction are set up which causes an intense form of pain.

The muscle coats of the *bladder* are strong at the bases and weak at the upper part. The upper part is the distensile part and in the fibres are many elastic fibres to assist, in the contraction of the bladder, to force the urine out. Near the base the muscle fibres loop around the the urethra through which the urine in discharged. This loop is a sphincter 括約肌 and acts as an automatic stop.

Usually the muscles contract to control the discharge of urine but when the bladder is greatly distended they automatically open. The other bladder muscles contract under distension, the sphincter relaxes. This is a sample of the automatic mechanisms of the body brought about by cooperation with the nervous system.

The discharge tube for the bladder is the *urethra*. 尿道 It is 8 inches long in the male and 1 1/2 in the female. There is a second automatic stop of cross fibred muscles in the urethra which is subject to voluntary control. It is about an inch beyond the first or involuntary stop and in the male lies just beyond the prostate gland and in the female at the outer end of the urethra.

The urine is a fairly concentrated solution. These substances in solution tend to crystalise out if there be a minute particle of solid matter in it. Such particles are formed sometimes in the kidney pelvis from nephrons killed and thrown off and thus *stones* are formed. These stones are more common and larger in the urinary bladder. Their nuclei being formed of dead epithelial cells or bacteria.

MUSCLE

(See "Hand and Brain")

The chief tissues of the body are; muscle, bone, fat, cartilage nerve and connective tissue. Muscle comes from the word "mus," a mouse, and means a little mouse. When you cut the sheath of a muscle a wave runs along the muscle tissue like a scurrying mouse.

Movement is the most striking and valuable trait of all animals. *All movements of the body are* made possible through the action of muscles.—Meat is the muscle of dead (i.e. without movement) animals used for food. Our reactions with our environment to persons and things are expressed in movement.

Many of the muscles of the body are responsible for its shape. Muscles are formed of a soft reddish material which peculiarly possesses the properties of contraction and expansion. In machines there is a push or shove but muscles *pull*.—Muscles may contract one half of their length. Their tissue is not homogeneous but is formed of an enormous number of fibres bound together by tissue into suitable shape for particular uses. There are over 4,000,000,000 muscle fibres in our bodies.

Besides all the mechanical work of the body, muscles produce practically all its *heat*. 熱 Their contraction and expansion generate heat.

Conscious visible movement is not the only movement of muscles, it takes more muscle activity to stand than to lie down—hence we have more heat on standing than lying, therefore, we use bed clothes for heat. Muscle is found whenever movement is needed—limbs, heart, intestines, blood, vessels, viscera of abdomen, etc. Muscle forms 50% of an athletic and 40% of an ordinary person's body.

While nearly all movements of the body are caused by contraction of muscles yet there are at least two other kinds of movement viz: (1) scavenger cells of connective tissue which engulf bacteria and debris. (2) movement of cilia; e.g. the interior of the nose and the trachea are lined with cells which have projecting processes called cilia. 睫

These move all together in a definite direction with a definite rhythm. They move debris from the interior to the exterior of the body.

Muscles have a *body or belly and two ends*. The ends are usually tendinous and are attached as a rule to bones. Through contraction of the muscles the joints, etc. are moved. The tendon does not contract, it just transmits the pull. The tendons are the hands of the muscles. Muscles are usually surrounded by a *thin sheath* and are independant units associated in definite groups.

Movements in all directions may be possible in certain joints. According to the movement they produce muscles are classified as *flexors*, 屈 *extensors*, 伸 *adductors* 內收 and *rotators*. 廻旋

Muscle tone; all muscles of body are in a constant state of tension called *muscle tone*—this is a state midway between full contraction and relaxation.

This tone is maintained while life lasts—it is considerably lessened in anaesthesia and with insensibility. Relaxion of tone is frequent in all muscles e.g. when a flexor contracts the opposing extensor muscle must relax gradually to permit movement and when the extensor contracts, the flexor relaxes.

There are *three particular kind of muscles*—Voluntary, 隨意肌 Involuntary, 不隨意肌 Cardiac. 心肌

There are three kinds of muscle fibres:

(1) Long striped (skeletal muscle or voluntary);

(2) Short striped (heart or cardiac);

(3) Smooth or plain (intestinal or involuntary).

These do not mix with each other but sometimes there is overlapping at junction points. Voluntary movements are produced by long striped fibre muscles, but they may act in a few involuntary movements, e.g. sneezing and coughing. This type of muscle makes up 696 of the *792 muscles of the body*. Muscle fibres are fine threads tapering at their ends. In length they vary from 1/25 to 2 inches (1 1/4 inches being an average length. It takes 600 side by side to make an inch.

Each fibre is striped transversely, 8,000 stripes to an inch, and between each transverse stripe are hundreds of still smaller fibrils running lengthwise, *There is a nerve fibre for each muscle fibre.* Each fibre of a muscle has its sheath with blood capillaries. The total length of all muscle fibres in an average person is 1 1/4 inch x 4,000,000,000=89,000 miles i.e. would extend nearly 3 1/2 times around earth at the equator. Single fibres have little strength—*the strength of muscles lies in group action.* The biceps sontains 360,000 of them. Fibres differ in size. As a rule fibres contract at the will's command—except those which give a muscle its "tone".

Slight tension is always present in living muscle. The movements of voluntary muscles are under the control of the brain. Muscle action can be shifted 40 times a second. Combinations of muscle fibres are limitless and we each learn from youth how best we can use certain combinations in the best way—no two persons use the same combinations. That is one reason why writing signatures identifies people. We play on our muscles as on an organ.

Experience teaches us what successive combinations of muscle fibres make harmonious movements. The central nervous system calls billions of muscle fibres into harmonious sequence of progressive actions. It takes about 40 stimuli from nerves to keep muscles in continuous action. A vast task indeed has the central nervous system to secure the rhythm and beauty of motion.

Muscle fibres of all kinds can contract automatically.

Each variety of muscle has been kept alive outside the body in proper fluid in a laboratory incubator.

Each fibre contracts rhythmically without outside stimulus at the rate of 70-120 a minute. The exact reason of this rhythm is not understood but it is believed that a change in surface tension of fibrils is the controlling factor.

MUSCLE ACTION IS OF FOUR KINDS.

Not all the fibres of a muscle act at one time and no muscle acts alone. When the muscles of the fore-arm act on the palmar side of the fingers they contract and bend the fingers towards the palm but some fibres of some of the finger muscles on the back of the forearm also contract at the same time even though their main action is to pull fingers from the palm. This action of muscles is called *antagonism*—the muscles of the front and the back of the fore-arm are *antagonists* 對抗作用 this mutual antagonism between muscles directs, controls and steadies motion. All muscles have antagonists which control, steady and cooperate together. A muscle does not act when gravity does it work for it.

Most bones have many tendon attachments and they may all pull at once—the motion assumed is the resultant of *all the pulls in the direction of the strongest pull*, it is the sum of many forces acting in different directions. All the muscles may, can and do act together. They are therefore *synergists*. **協同作用** The muscle making the strongest pull on the bone at any one moment is called the *prime mover* of that momentary motion. *Antagonists* and *synergists* join to modify motion.

Gravity is a constant factor in muscle action both assisting and opposing. Without gravity all muscle movement would be changed.

If we grasp with our hands something above our heads and pull, the abdominal muscles contract forcibly. Why so in arm motions? It is because they hold the bones of the chest firmly so that the shoulder muscles which connect the arm to the body will have, a firm base from which to act. This is called the action of *fixation*. When standing and working with the arms and hands all the muscles from the feet to the arms are engaged in fixing.

Muscles therefore act in four ways—*prime movers, antagonists, synergists* and *fixers*.

One cannot easily learn the function or action of every individual muscle. It is better to group the muscles as to function e.g. of the four muscles of the quadriceps extensor, group of the thigh, each has an individual function but for practical purposes, study that *muscles' combined action*—It is essential to know the general course of the nerves and arteries so that these may be borne in mind in referance to possible damage by the ends of fractured bones. This is especially necessary in considering the nerves from the brachial plexus to the upper extremity.

SPECIAL MUSCLES.

Muscles of expression: The muscles of the face arise usually from bone or the deep fascia and are *mainly inserted in the skin*. Thereby the facial expression of emotions is portrayed. There are in connection with the *ear* 3 muscles that could move the ear in 3 directions but they are too feeble so to do. In the foetus the ear and facial muscles are connected together in one sheet. All of these are formed from the intestinal canal musculature. Emotions may embryologically be originally from the body and not from the reasoning part of the brain.

Muscles of the eyes. The eyeball has six muscles attached to it; four rotate it up, down, right and left; two roll it top in and top out. These muscle coordinate, the muscle of the right eye (lateral side) works with the one on the median side of the left eye, etc. This coordination is harmonious and is effected unconsciously by the brain.

The *omohyoid* 肩胛舌骨肌 serves the vascular system. When it contracts it prevents the deep fascia of the neck from being depressed. It thereby assists the blood circulation. (See circulation of blood.)

The *flexor muscles of the fingers* are somewhat shorter than the extensors. Thus the *resting position* of the hand is one in which the fingers are flexed; they and the thumb all turn towards the palm. *The resting position is important because then there is the least strain and repair goes on most rapidly.* This position may not be the best working position and in case of injury of e.g. the fingers when ankylosis will occur the surgeon may *not* want the part *fixed* in this position. In cases of fracture with no complications in the joints and *particularly in fractures of the forearm the position of rest is usually the best position* i.e. put the arm half may between provation and supination.

The *muscles of the abdomen* and thorax are of three layers. This construction gives strength. In case of an incision through the three layers, the contraction of the muscle fibres in three directions prevents the persistance of an opening but it is always wiser when possible to make the opening through the layers by tearing not cutting the fibres in *the normal direction of their pull.*

The *diaphnamn.* 膈肌 The innermost of the three layers of the thorax is almost entirely absent. During development this layer moves down and becomes the diaphragm. It is present only in mammals. It protects the heart and lungs lying above it from the high abdominal pressure which results from great bodily activity. It, with the abdominal muscle, produces the greatest abdominal pressure which is an essential factor in the birth of the young. The position of the diaphragm in mammals protects the heart and lungs from overdue pressure during parturition.

The *pyramidalis muscles* 稜錐肌 is apparently a vestigial remnant. In the opossum etc this muscle is attached to a bone outside the pouch for their young and its contraction serves to open the pouch. In man its function is unknown.

TENDONS 肌腱

(See Tendons and Tendon Sheaths of the Hand).

The body of the muscle does the work—the fibre of the muscle contracts individually when it gets its call from the brain. The belly of the muscle is formed of these muscle fibres. The ends of the muscles have *tendons.*

Some tendons e.g. of fingers of the hand are 12 in. long. Such a finger tendon is composed of thousands of slightly wavy white fibres of bluish iridescent convective tissue all in parallel series and arranged in bundles. Some elastic fibres may be amongst the connective tissue fibres. Each tendon fibre is attached to a muscle fibre so closely and firmly that the force of the muscle will not break the tendon fibre. The muscle fibre would break before the tendon fibre gives away. Such an injury is called "Charley horse" by athletes.

The tendon has a delicate sheath continuous with the muscle sheath. This sheath carries blood vessels to nourish muscle, and lymph vessels to carry off the debris muscles and nerves. Some muscle fibres do not reach the tendon and their pull is made on sheath which transmits it. There are some fibres in the connective tissue sheath which run crosswise of the muscle. These prevent too great expansion of muscle —the expansion at middle of the muscle being in proportion to contraction of ends.

The length and position of the tendons and the size and position of the muscle reveal the beauty and mechanical adjustment. When muscles overlie each other the lower one is apt to be tendinous because the overlapping prevents its contraction lengthwise. Opposite joints where a mass of muscle would prevent the bending of the joint the muscles are tendinous. When a muscle is in two parts as the omohyiod and the ends go in different directions the pivotal point is tendinous.

Muscles mass is disposed about the bones of the limbs to give them beauty and give the correct shape for mechanical use or function. If the muscle is sometimes far from the parts on which it acts then there are long tendons. To prevent tendons from pulling away or sliding sideways from a joint during its movement the tendons are held by ligaments and they slide in grooves on the bones. Some muscles act on parts which are separated by two or more joints in such cases as in the fingers some tendons are very long. Some fore arm muscle tendons acting on the end of the fingers pass over six joints. These tendons are held down by ligaments at the wrist and on the fingers. On the palmar side of the hand such ligaments are joined to form a tunnel through which the tendons glide. At the ankle the tendons work somewhat differently.

Lubrication of tendons—under tendons such as at the fingers and the wrist—friction between tendon and ligament is provented by bursae. These are closed sacs containing lubricating fluid they do not entirely surround the tendons—for on the edge facing the bones there is a space for nerves and vessels from the bone to pass to the tendon sheaths of the thumb and little finger are longer than on the middle fingers. Thus infected wounds of the thumb and little finger tendon sacs are more extensive and hence more dangerous. Most tendons are attached very securely to bones (externally and internally) so that the bone will often tear before the tendon does. All muscles have tendons of some sort but they differ. Some tendons, as in the face, are attached to the skin and produce skin movements in facial expression. In the tongue, tendons are attached to connective tissue and so cause it to lengthen or shorten, curl its tip or move side to side. On the front of the abdomen the tendons are broad and flat like membranes. Between the ribs tendons are so short they are not seen. Tendons sometimes concentrate the action of a large muscle at a small spot e.g. deltoid, biceps, and psoas etc. Again in the fingers the action of the muscle mass is divided and acts on several tendons to different parts.

The abdominal muscles move the thorax and hold it firmly as a base for arms etc., but the abdominal wall has no bone in its anterior part to interfere with bending and breathing so the tendons are woven into a tough elastic membrane which gives strength with flexibility.

SKIN.

The skin is the chief agent of the body in its relation to the body's environment. It is the cover of the body. It must be sensitive to react to its environment. It must defend the body against violence, loss or ingress of water; and, other fluids and materials.

It must keep out bacteria and poisons, it regulates the temperature which is constant, if the body is in health; it provides for both retention and loss of heat; it provides weapons of defense and offense; it is exposed to wear and tear, and renews its surface that is scraped away; it provides nourishment for the infant; it keeps the surface of the eye covered with salt water; it forms a tube that allows air waves to get to the ear drum and keeps insects out; it provides a firm gripping, nonslipping surface for the hands and feet.

The total *weight* of the skin is about 6 lbs; its *area* about 20 sq. ft.; its thickness .5-.4 mm *varies greatly*. The relation of *skin surface to body weight* is important in relation to air contact, ease of movement and for radiation of heat.

The infant with more skin in proportion to body weight gets cold more quickly than the adult.

The skin absorbs from the sun certain rays which are health giving.

The skin not only is a protection against the entrance of bacteria but probably also has a bactericidal action.

The skin is elastic and varies from 1/50--1/6 in. (.5mm-4mm.) in *thickness*. It is thinnest in eyelids and prepuce, and thickest over back of neck, back of shoulders, palms, and soles. Its *color* depends in part on the blood and in part on the pigment 色質. The deepest hue is at anus, genitals, 生殖器 axillae, mammary glands, and the parts exposed to light and temperature. Color varies with age—pink in babe, and yellow in old age. It varies with exposure and climate being deepest with tropical sun exposure. It varies with the *race*, e.g. white, yellow, brown, and black races. Certain *diseases* change color, e.g. pale in anaemia, brown in Addison's, yellow in jaundice, etc.

The skin is usually *moveable*, sometimes is closely attached, e.g. scalp, palms, soles, and outer portion of pinna 耳郭 of ear. The skin is fairly *smooth* but it has multitude of openings, creases 摺, furrows 溜, depressions, folds, and hairs. Hair follicles 囊 open upon the surface, also ducts of sebaceous and sweat glands.

When the skin is punctured by an awl it tends to split in definite ways. These clefts are called *cleavage lines* 分裂 (G 872-3) of Langer and depend upon arrangement of connective tissue bundles 束 in the corium 眞皮, and these bundles influence the formation of folds and furrows.

The skin consists of two *layers:* epidermis and dermis. 1. *Cuticle*, *Epidermis*, or Scarf skin, is composed of layers of epithelium and is derived from ectoderm 外胚葉. It is stratified 表皮角質層 and is devoid of blood vessels. There are two layers: (*a*) superficial or horny, (*b*) deeper or Malpighian.

Horny: layers of non-nucleated scaley cells—cells of keratin. The surface cells are being constantly rubbed off, and being replaced from Malpighian layer which becomes converted into keratin 角素. Malpighian layer is divided into four:—

(1) Stratum lucidum 光層,

(2) Stratum granulosum 粒層,

(3) Stratum mucosum 洒膜層,

(4) Stratum germinativum 表皮生發層,

2. *Corium, cutis vera, dermis, or true skin* is a connective tissue which arises from the mesoderm. It consists of connective tissue and elastic fibres. It contributes elasticity to the skin, and is the seat of sense organs, it is of two layers:

papillary and reticular. The *Papillary* layer lies just below the epidermis and contains the papillae. It is composed of fine bundles of fibrous tissue, papillae of fine connective tissue, and elastic tissue. They project from the corium and enter depressions in the epidermis.

In the face, especially the eye-lids, they are insignificant. On the penis, palms, soles, and nipples, they are large. In palmer surface of fingers and toes they produce permanent ridges. Ducts of sweat glands emerge, between rows of papillae and open on curved surface ridges. Most of papillae contain capillaries—vascular papillae. Some of the papillae contain nerves—nerve papillae.

The *Deep*, or *Reticular*, rests on subcutaneous tissue. It passes into the papillary layer and into subcutaneous layers with sharp line of differentiation. In the nipple the deep layer of corium lies on muscle. In the face this muscle tissue is striated 紋 and sends prolongations to papillary layer. In nipple and scrotum it is nonstriated. The reticular layer is composed of bundles of white fibrous tissue arranged in net-work. In the meshes of network are fat, blood vessels, lymphatics, sebaceous glands, sweat glands, and hair follicles.

The *subcutaneous areolar tissue* connects the skin to parts beneath and in most regions it contains fat, but in scrotum, eyelids, external ear, and penis there is no fat. When fibres of this tissue are long and nearly parallel to the skin the skin becomes wrinkled, when short and at right angles to skin it cannot wrinkle.

Superficial or *Skin Reflexes:* In stroking the skin in certain parts of the body there is a definite reaction from the irritation and this reaction is due to a nerve reflex, e.g. in stroking the inner side of the thigh the testicle is drawn up. In some diseases this reflex are is partially or wholly inhibited 阻止 e.g. syphilis. In other diseases the reaction is increased, e.g. in hysteria癔症(神經昏亂病). Sometimes the reaction is absent in health.

The epidermis is the important part of the skin and performs all of its functions. The dermis serves for nourishment, support and mechanical strength. The horny layer of the epidermis is the one which comes off in some reptiles during their molting season.

The 3rd and 4th layers are alive. The stratum mucosum is very active growing. Its cell spaces are filled with fluid and it is a continuous tough spongy layer forming a water cushion all over the body for the 4th or most important layer. When one is burned the fluid of this 3rd layer increases and a "blister" is formed.

The 4th layer is the germinative constantly growing part.

Modifications of the skin. From early development the ectoderm becomes the brain and spinal cord and from it the nerves grow out. *Sweat glands* regulate the temperature of the body. These grow from the surface of the dermis. They reduce the temperature of the body by taking water from the blood stream and pouring it out by evaporation on the skin surface.

Since the body is 85% water these glands provide a prompt and efficient cooling apparatus. The *hair* is purely epidermal. (See "hair") Finger and toe *nails;* the epidermis provides in animals weapons of offense and defense by the nails and in some species through the hair, e.g. quills of the porcupine and the horn of the rhinoceros. The nails of the fingers grow about 1/250 inch in a day and the toes 1/3 as fast.

Teeth. The epidermis dips into the nose and mouth and makes the lining from which the teeth grow. The hard enamel is produced by the epidermal covering of baby teeth before they grow through the gums. *Tear glands* are formed from the epidermis and prevent the drying of the surface of the eyeball.

Milk glands. These are modifications of the epidermal skin glands. *Sebaceous* glands secrete a fatty substance which oils hairs and other parts.

Ear. In the external ear there are modified epidermal glands which secrete an oily fluid which becomes ear wax. This is a protection against insects. The internal ear is part of the ectoderm and is sensitive to sound, air, water and bone vibrations.

Nose. a part of the ectoderm dips into the nose and becomes especially sensitive to smell.

COLOR OF SKIN

(Ethnologically) 人種區別學.

Physiology explains color as a consequence of climate and dirt. The pigment or coloring matter under the epidermis or rather under the 2nd, or Malpighian skin, is not peculiar to the negroid 黑種 and other colored races, but is common to all human beings.

It is simply more abundant in certain peoples and this abundance is attributed to the stimulating action of solar heat combined with moisture and an excess of vegetable food yielding more carbon than can be assimulated 使同化, the character then being fixed by heredity. "The hotter the climate the darker the negro". If you follow the line of greatest heat from Africa into Asia it is in those two regions that the darkest people are found. Exceptions to this are due to local causes. An author states that the reddish tint of the ' onges of the hot moist White Nile 尼羅河 District is due to ferruginous 鐵的 nature of the soil. In South America all shades intermingle. In Australia are yellow brown Malays 馬雷種 and sooty black Tasmanians. Such deviations from color-law may be attributed to descent (dark people migrating to cold climates, light to tropical countries) or to such varied causes as dryness, moisture, food, vegetable peculiarities of the land; by all of which the complexion may be affected and influence of temperature mitigated 和緩.

The color of skin is not therefore a trustworthy racial asset, even blackness is not exclusively negroid. Man is divided into white, yellow and black races (Europo-America, Asia, Africa). Interbreeding and the influence of environment 外圍 have caused the occurrence among the three groups of almost every shade and tint of complexion 顏色. The skin color therefore varies widely in same ethnic groups, and races of one group resemble in this particular races of another. The palms and soles of a negro are never black, and in all colored races the back of the body is a shade darker than the front.

The skin of the colored races is always a lighter tint in the new-born than in the adult. The negro baby is light grey and the dark pigment is absent in negro foetus. From the third to eighth day the color changes to a hue nearly same as its parents. It would seem the blackness is associated with the general thickening of the skin and is an accompaniment 相隨 of the general organic 器官 adaptation 適合 of the negro to his hot malarial climate.

The effect of sunburn varies in races. It is with the races having intermediate pigmentation such as the dark European and yellow races that the effect is most noticeable. With the former the sun burns the skin uniformly making them mulatto tint. The color so acquired is merely temporary. It diminishes in winter and disappears entirely on return to cold temperate climate.

With the Asiatics the sun causes different tints. The skin of Indo-Chinese become dark olive, as also the Malays.

The Fuegeans and Galilies turn brick color to dull red. The Chinese skin turns darker in winter and paler in summer. Among certain peoples whose skin is normally black the parts of the body exposed to light and air are often lighter than those covered by clothes. This is the case with the Fuegeans and Sandwich Islanders. The fair Europeans redden under the sun passing from pale red to brick red or to patches of deep red.

COMPARATIVE ANATOMY OF THE SKIN.

In the larval stages of the Amphioxus cilia 細毛 are present on the surface, and in the superficial epidermal cells of some fishes and amphibian 水陸兩棲門 larvae is a striated layer on the free edge which is looked upon as a relic of ancestral cilia 睫.

(*a*) Skin glands of the cyclostomata 圓口門 (hags, lamphreys and fishes) are generally unicellular and secrete slime 粘質物 which protects the surface of the body; the amount of slime poured out by some cyclostomes 圓門口 is enormous. Many of these slime cells from their shape are called goblet cells. Some of the telostean fish have poison glands at the bases of their dorsal fins and opercula.

Dipnoi (mud fish) and amphibians multicellular spherical cells appear as involutions 包在內 of the ectoderm. Sometimes, as in so-called parotids of toads, these form large masses. *Reptiles* and *birds* are singularly wanting in skin glands, though the latter have a large uropygial gland at the root of the tail which secretes oil to lubricate the feathers: it is the chief constituent of the "Pope's 羅馬敎王之鼻 nose" of the fowl.

In mammals, except the Cetacea 鯨魚, the sebaceous and sudoriferous glands, as in man, are found. Some of the former sometimes attain a large size as in the interdigital gland of the sheep, Muller's gland at back pig's knee and the suborbital gland of ruminants 反芻類.

In addition to these, special scent producing glands are often found in different parts, the most remarkable of which are scent 香氣 glands beneath the tail of the skunk 臭獸; while in mole monotremes 單肛門動物 there is a special poison gland in the leg which is connected with a spur in the foot.

Pigment cells are present both in dermis and epidermis of fishes and amphibians, and the pigment may be either intercellular or extracellular. In many cases it is under the control of the nervous system so that forms like the flat fish and common frog 蛙 can adapt their coloration to that of their background. In animals permanently excluded from the light pigment is absent.

In reptiles moveable pigment cells are often found, as in the chameleon 蜥蜴; 龍子 while in birds the pigment is sometimes of great brilliancy in the necks and wattles 枝.

In mammals as in man the pigment is confined to the cells of the stratum mucosum layer of the epidermis.

Scales. In the elasmobranch fishes scales are found composed of enamel 釉戻 superficially and of dentine and bone deeply. They are developed from the epidermis and dermis and in almost every way resemble the teeth of these animals which are only modifications of them. The bony basal part of each scale is plate-like, hene-placoid.

In the ganoid fishes, e.g. sturgeon, much larger placques called ganoid scales form a complete armature.

In the teleostean fishes the scales overlap like tiles and are either cycloid, having a smooth border, or ctenoid in which free posterior border is serrated 鋸歯形. Existing amphibians are usually remarkable for absence of any skin armour 盔甲, though in fossil 化石 forms stegacepholia it is very complete. The reptilian class have epidermal scale. In the ophidia they are cast off periodically in one mass as snakes slough 蛇蜕, while in Chelonia they form tortoise 龟 shell. Bony structures developed in the dermis may underlie the epidermal thickening (horny), and are very strongly developed in dorsal and ventral shields of the chelonia and plastran which secondarily fuse with the true endoskeleton. The armadillo 犰狳 is the only mammal which has a true bony exoskeleton.

Feathers are highly modified scales. The embryonic or down feathers are simple and consist of a brush of hair-like barbs springing from a basal quill or calamus. From the whole length of each barb a series of smaller barbules comes off like branches of a shrub. The adult or contour feathers are formed at bottom of the same follicles which lodge the down feathers and by their growth push them out. The barbs and barbules grow enormously and in the tail feathers are connected by minute hooks, hence have a more resistant texture than in the feathers of the back and breast.

The birds' moult 脱毛 is comparable to the casting off the scales in reptiles.

Hairs are only found in the mammalian class and are divided into long tactile bristles 剛毛 or vibrissae, and smaller hairs which protect the body warmth. In some animals the hair of the body is composed of long stiff hair which are probably specialized for protective purposes, and short soft hairs for warmth. These long hairs may be greatly enlarged and hardened as in the porcupine 豪猪, hedgehog 猬, spiny mouse, and anteater (echidna).

Horns: 1, Antlers 角叉 2, hollow horns, 3, hairy horns (rhinoceros) 犀牛 *Antlers* are growths of true bone and except for very vascular covering of skin (velvet) are not exaskeletal structures. They grow with rapidity and in the deer family are renewed each year. As soon as their growth is finished the skin covering dries up and strips off. The small horns of giraffes 麒麟 are also bony structures but permanent.

The *hollow horns* of ruminants (bouidiae) are cases of hardened epidermis which fit over a bony core and are permanent. Found in both sexes. In the prongbuck (antilocapa) the hollow horns are shed.

Hairy horns of rhinoceros are a mass of hairs cemented together by cells. The hairs grow from dermal papillae but differ from true hairs in not being sunk into hair follicles.

Claws and Hoofs 爪蹄 are modification of nails spread in case of hoofs over the whole digit. Nails appear embryonically at the very tip of the digit and in this position it remains in many amphibians 兩棲類, e.g. giant salamander 火蛇, while in hoofed animals it develops both ventrally and dorsally. In the Felidae the claws are retractile but the real movement occurs between the middle and terminal phalanges of the digits.

Spurs are distinct from nails and claws. In birds are horny epidermal sheaths covering bony outgrowths of the radial side of the carpus 腕, metacarpus 掌, or metatarsus 蹠. The spur-winged goose has a carpal spur. In screamers (palamedea & Chauna) the spur or spurs are metacarpal while in many gallinaceous 鷄類的 birds (common fowls and pheasants) metatarsal spurs are found. In the mammals the mole 田鼠 monotremes (echidua & ornithorhynchus) have spurs attached to an extra (? sesamoid) 滑骨 bone in hind leg perforated for poison gland duct.

Beaks. Some fishes (mormyridae) have fleshy prolongation of lower lip and are called beaked fish. In amphibia

Siren and the tadpoles 蝌蚪 of most Anura (frogs & toads) have small horny beaks. In the reptilia horny beaks are found in chelonia, while in birds beaks replace the teeth in modern species. In mammals a horny beak 喙 is found in ornithorhynchus 鴨嘴獸, coexists with the true teeth and horny pads in adults. All these beaks from cornified epidermal scales.

Baleen (whalebone) 鯨魚骨 flattened triangular horny plates on either side of palate. There may be hundreds of them and 10 feet long. It consists of epidermal hair-like fibres cemented together and growing from dermal papillae, not true hair follicles.

HAIR

The hairy coats of mammals, like the feathers of birds, were begot not as ornaments nor as coverers of shame. It matters not what secondary use may afterwards be made for hairs and feathers; *their primitive function is to conserve the bodily heat* produced by activities of the expiratory and circulatory systems.

The following explanation, briefly given, is appended— The early Jurassic precursors of mammals were generalized reptiles—with a sluggish life—whose limbs were not fully perfected to support their body weight; they did not constantly carry their bodies clear of the ground. In general, their progress was made by dropping the greater part of the body length along the ground. It was only when the animal stood always clear of the ground and became more activated that a more rapid metabolism was developed.

It was this activity, due to developement, that begot the real present day mammal. The internal metabolic change called for the production of an external alteration, for the hitherto naked or scaled skin of the premammal permitted too great a loss of heat. The epidermis reacted and an epidermic outgrowth of hairs was produced, probably a derivative of the scales. A hairy covering thus became distinctive of small and active animals from which the mammals were derived. Secondary uses are made of hair, but it has never been bartered away from the original protective role of conservation of heat unless other means adopted to fulfil that function. When hair upon the surface of the body becomes undesirable, then loss of heat may be prevented by the developement of a protective layer beneath the skin instead of on its surface, for example, blubber in whales and other aquatic animals. Did man lose his hair because he took to protecting himself by artificial covering? A large section of mankind who go without clothes have no compensatory developement of body hair. Indeed in the negro races the opposite is the case, for in these unclothed groups there is less hair than an average white man. It would seem that man has developed a heat retention system rendering hairy or even other covering (as clothing) unnecessary at least in part and under certain climatic conditions.

The dissector will quickly realize this condition—in his first attempts to "skin" his subject—very few animals are as difficult to skin as is man—owing to the superficial fascia which is the subcutaneous barrier against heat loss developed in man. Even in monkeys it is easy to remove the skin —by incising and pulling it off and turning skin inside out as one does a rabbit. In man skinning is a laborious process, for there is an intervening pad of fibrous tissue and fat between the skin and muscle rendering the skinning process difficult. Some other animals which have naked skins present the same difficulty. The layer under discussion, for example, the blubber in whales, is well developed. Man thus has his own anatomical compensation for his loss of hair. His clothes may be more or less simply an aesthetic luxury.

This subcutaneous fat layer gives man rounded contour which we think beautiful. The aged and skinny look of monkeys is nearly matched in the human foetus before the fat layer is developed; the 6th month foetus has an "old man" or even monkey aspect which is lost as the subcutaneous layer is developed in the later months of foetal life.

Man is specifically a relatively hairless animal and his body hair has not necessarilly disappeared as a consequence of wearing clothing. The hairy coat is disposed over the body of man in an orderly fashion by being arranged in definite tracts in a definite direction and are separated from neighbouring tracts by partings, whorls or vortices. The hair tracts of the hand are herewith only considered. As an animal moves forward one border of the limb will be in advance of the other; there is a front and back edge to each limb and hand and foot. In other words, each limb has a pre-axial and a post-axial border.

The pre-axial border is the advancing border and any other arrangement would lead to the hair being rubbed the wrong way as the animal progressed. In terms of human anatomy, one would expect that the hair on the fingers and hand would be directed from the thumb (preaxial digit) towards the little finger (postaxial digit). This simple state of affairs is commonly not appreciated—from it one can determine from which side a finger has been amputated. Hair is not uniformly distributed over the dorsal surface of the hands and digits; it is absent, as a rule, over the actual knuckles and grows more freely as tufts upon the dorsum of the phalanges. Upon the radial border of the hand the hair is more scarce than upon the ulnar side and the thumb is very often practically devoid of hair. The tuft on the basal phalanx is usually well marked and it will be readily seen that the tips of the hairs composing these tufts point to the postaxial margin, i.e. towards the little finger or towards the side to which the finger belongs. The tufts on the medial phalanx are usually less developed and the terminal phalanx is always totally devoid of hair. Upon the toes the growth of hair is generally more developed than it is upon the fingers, and its disposition is in all respects similar to that described on a typical hand.

As with body hair in general, the hair upon the hands and feet of women is less well developed than it is in men. A man practically always has hair upon the basal phalanx of the big toe, while this tuft is commonly absent or but little developed in a woman.

FACTS ABOUT HUMAN HAIR

Barely a century ago, says Dr. Arthur Selwyn Brown, *writing in Popular Mechanics* (Chicago), human hair, on account of its physical qualities, was largely used for scientific and artistic purposes. Makers of scientific instruments employed hair for the angle markers in telescopes, surveyors levels, clinometers and other apparatus. Its strength permitted them to use it for suspending fine pendulums and similar moving parts. Its property of absorbing moisture made it valuable for hygrometers. About fifty years ago numerous steels alloys ware discovered that may be used for drawing into very fine wires, and these convenient alloys led instrument makers to select them in place of hair. He goes on: "Hair is distributed all over the human body, except the palms of the hands, the soles of the feet, the lips and the eyelids. Its thickness varies in accordance with the part of the body it is growing on. The head, face and chest have the thickest and longest growth. There are about 1,200 hairs per square inch on the top of the head of a middle-aged man, and 160 per square inch on the face. There is less than half this quantity on the chest. Race, sex, age, condition of health, habits and climatic changes all influence the thickness and growth of the hair. "A woman with black hair has about 600 hairs per square inch on the top of the head, while a blonde has 760 per square inch, and a brown-haired person has about 650 hairs per square inch. A black-haired person usually has the thickest hair and a blonde the finest. The total number of hairs on the head of any ordinary black-haired woman is about 110,000, while a blonde has 150,000, and a redhaired woman only 30,000. A woman's hair is coarser and heavier than a man's, and it grows longer. The average length of hair of women of the Anglo-Saxon race is from eighteen to thirty inches, and that of men between six and ten inches. Men's hair will seldom grow as long as women's." The average speed of hair growth is two inches per month, Dr. Brown tells us. The period of growth of the hair on the head is about six years, and the eyelashes have a life of about 130 days. After these periods, the hairs wilt and fall out. Hairs grow just as new cells replace the dried cells of the skin that wither and fall off like scales. To quote further: "The hair is a very acute sensory organ and assists the brain and other organs to discharge their surplus energies. In animals, certain hairs are developed into exceedingly alert and sensitive sense organs. It is a peculiar growth of the epidermis or skin. In this respect it resembles the nails, the horns of cattle, the feathers of birds, the quills of the porcupine, the scales of butterflies, moths and fish and the shell of the tortoise. "Hair is easily colored and, in nature, the pigments it contains are peculiar to the species. The duration of its pigmentation in life is limited. In man, we may, in a brief period, witness a child having a bright golden hair, which soon changes to a dark or black and then to a gray or silver-white and dies at maturity and falls out, leaving baldness. In the animal kingdom, we may notice similar changes in the pigmentation and also many abnormalities in its life, particularly in those animals which periodically molt and shed their hair. "Scientists believe that hair has a high value as a racial characteristic. The microscope discovers that the structure of hair has multiform variations and these may be clearly defined and utilized for personal and racial determinants, like finger and other skin prints. Common observation shows that the texture and form of the hair of a Negro, Chinese, American Indian and a Caucasian differ in quantity, color, structure and growing habits. All through the animal kingdom we may find similar differences in all the species. A man's race, nationality, character and the condition of his health may be shown by a microscopic investigation of one individual hair."

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